A CAHNERS PUBLICATION INTERNATIONAL EDITION JUNE 21, 1990

Bulletin Board P276

EDN®

Undersampling reduces data-acquisition costs

Isolation barrier passes transducer signals

Electrostatic plotters

Prototyping makes ASIC design less risky

19 JUL 1990

ELECTRONIC TECHNOLOGY FOR ENGINEERS AND ENGINEERING MANAGERS

Special Report: Analog-simulation software converts PCs into design tools



88 Pin "DAC-Per Pin" Technology

NEW

From $1995.00*



ALLPRO-88™ Universal Software Driven Device Programmer Supports Virtually Every Device On the Market!

Logical Devices can give you a truly pin driven "DAC-Per-Pin" programmer with electronic ground and Vcc, 4mHz clock, current mode source, high-speed programmable slew rate, and up to 10 amps peak of current on each pin.

All of this starting at $1995.00 for a 24 pin version with logic configuration. Easily field upgradable to 88 pins. Supports the latest of low to high-pin count devices such as the AMD Mach and Altera Max devices, National "D" PALs, Signetics PLHS Series and all of the devices your current programmer cannot program!

Supports programming, verifying, and functional testing for PLDs, EPLDs, GALs, PALs, PROMs, EPROMs, EEPROMs, FPGAs, LCAs, MAX, MACH, ASPL, P-Sequencers, and FPLAs. ALLPRO is certified by key semiconductor manufacturers to provide excellent programming yield and reliable operation.

No copy protection in ALLPRO-88 software and updates. Buy one copy for all your units. Updates are complete and comprehensive, each version includes all supported devices.

ALLPRO-88 is supported by CUPL®, the world's most popular logic design software, with high level behavioral hardware language (CHDL) multiple PLD design, ATVG and simulation capability.

If all of this gives you an upset stomach over your Model 29B investment, then call us for a FREE DEMO and a generous trade-in offer.

1-800-331-7766

LOGICAL DEVICES, INC.

1201 NW 65th Place
Fort Lauderdale, FL 33309
Fax: (305) 974-8531 Phone: (305) 974-0967

* Quoted price for US delivery only, F.O.B. Fort Lauderdale, FL.

The brands or product names mentioned are trademarks or registered trademarks of their respective holders.
© 1990, Logical Devices Inc.

CIRCLE NO. 179

TINY SPDT SWITCHES
ABSORPTIVE... REFLECTIVE



dc to 4.6GHz from $32.95 (10-24)

Tough enough to pass stringent MIL-STD-883 vibration, shock, thermal shock, fine and gross leak tests... useable to 6GHz... smaller than most RF switches... Mini-Circuits' hermetically-sealed (reflective) KSW-2-46 and (absorptive) KSWA-2-46 offer a new, unexplored horizon of applications. Unlike pin diode switches that become ineffective below 1MHz, these GaAs switches can operate down to dc with control voltage as low as -5V, at a blinding 2ns switching speed.

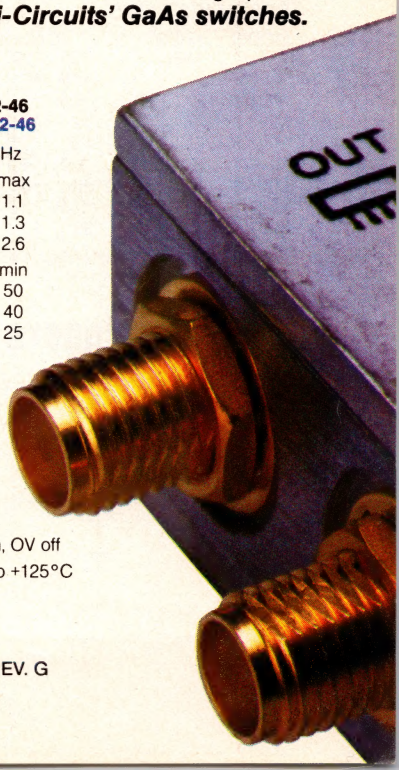
Despite its extremely tiny size, only 0.185 by 0.185 by 0.06 in., these switches provide 50dB isolation (considerably higher than many larger units) and insertion loss of only 1dB. The absorptive model KSWA-2-46 exhibits a typical VSWR of 1.5 in its "OFF" state over the entire frequency range. These surface-mount units can be soldered to pc boards using conventional assembly techniques. The KSW-2-46, priced at only $32.95, and the KSWA-2-46, at $48.95, are the latest examples of components from Mini-Circuits with unbeatable price/performance.

Connector versions, packaged in a 1.25 x 1.25 x 0.75 in. metal case, contain five SMA connectors, including one at each control port to maintain 3ns switching speed.

Switch fast... to Mini-Circuits' GaAs switches.

SPECIFICATIONS

Pin Model / Connector Version		KSW-2-46 / ZFSW-2-46		KSWA-2-46 / ZFSWA-2-46	
FREQ. RANGE		dc-4.6 GHz		dc-4.6 GHz	
INSERT. LOSS (db)		typ	max	typ	max
dc-200MHz		0.9	1.1	0.8	1.1
200-1000MHz		1.0	1.3	0.9	1.3
1-4.6GHz		1.3	1.7	1.5	2.6
ISOLATION (dB)		typ	min	typ	min
dc-200MHz		60	50	60	50
200-1000MHz		45	40	50	40
1-4.6GHz		30	23	30	25
VSWR (typ)	ON	1.3:1		1.3	
	OFF	—		1.4	
SW. SPEED (nsec) rise or fall time		2(typ)		3(typ)	
MAX RF INPUT (bBm)					
up to 500MHz		+17		+17	
above 500MHz		+27		+27	
CONTROL VOLT.		-8V on, OV off		-8V on, OV off	
OPER/STOR TEMP.		-55° to +125°C		-55° to +125°C	
PRICE (10-24)		**$32.95**		**$48.95**	
		$69.95		**$79.95**	



finding new ways...
setting higher standards

Mini-Circuits

A Division of Scientific Components Corporation
P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500
Fax (718) 332-4661 Domestic and International Telexes: 6852844 or 620156

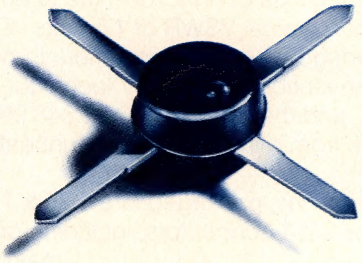
WE ACCEPT AMERICAN EXPRESS

C 117 REV. G

CIRCLE NO. 3

99¢

from



dc to 2000 MHz amplifier series

SPECIFICATIONS

MODEL	FREQ. MHz	GAIN, dB 100 MHz	1000 MHz	2000 MHz	Min. (note)	•MAX. PWR. dBm	NF dB	PRICE $ Ea.	Qty.
MAR-1	DC-1000	18.5	15.5	—	13.0	0	5.0	0.99	(100)
MAR-2	DC-2000	13	12.5	11	8.5	+3	6.5	1.50	(25)
MAR-3	DC-2000	13	12.5	10.5	8.0	+8□	6.0	1.70	(25)
MAR-4	DC-1000	8.2	8.0	—	7.0	+11	7.0	1.90	(25)
MAR-6	DC-2000	20	16	11	9	0	2.8	1.29	(25)
MAR-7	DC-2000	13.5	12.5	10.5	8.5	+3	5.0	1.90	(25)
MAR-8	DC-1000	33	23	—	19	+10	3.5	2.20	(25)

NOTE: Minimum gain at highest frequency point and over full temperature range.
• 1dB Gain Compression
□ +4dBm 1 to 2 GHz

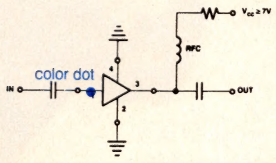
Unbelievable, until now…tiny monolithic wide-band amplifiers for as low as 99 cents. These rugged 0.085 in.diam.,plastic-packaged units are 50ohm* input/output impedance, unconditionally stable regardless of load*, and easily cascadable. Models in the MAR-series offer up to 33 dB gain, 0 to +11dBm output, noise figure as low as 2.8dB, and up to DC-2000MHz bandwidth.

*MAR-8, Input/Output Impedance is not 50ohms, see data sheet. Stable for source/load impedance VSWR less than 3:1

designers amplifier kit, DAK-2

5 of each model, total 35 amplifiers

only $59.95



Also, for your design convenience, Mini-Circuits offers chip coupling capacitors at 12 cents each.†

Size (mils)	Tolerance	Temperature Characteristic	Value
80 × 50	5%	NPO	10, 22, 47, 68, 100, 220, 470, 680, 1000 pf
80 × 50	10%	X7R	2200, 4700, 6800, 10,000 pf
120 × 60	10%	X7R	.022, .047, .068, .1μf

† Minimum Order 50 per Value
• Designers kit, kcap-1,50 pieces of each capacitor value, only $99.95

finding new ways...
setting higher standards

Mini-Circuits

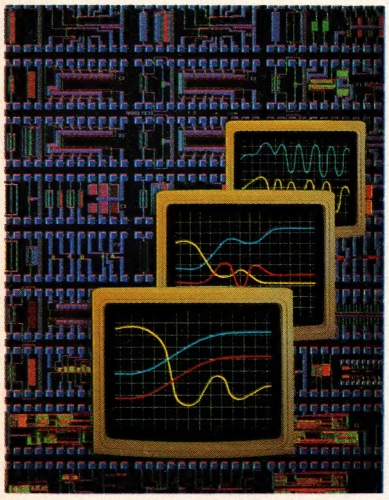
A Division of Scientific Components Corporation
P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500
Fax (718) 332-4661 Domestic and International Telexes: 6852844 or 620156

C113-Rev. D

EDN Magazine Edition

Volume 35, Number 13 June 21, 1990

ELECTRONIC TECHNOLOGY FOR ENGINEERS AND ENGINEERING MANAGERS



On the cover: *Stand-alone analog-simulation software converts the PC in your lab into a sophisticated design tool. See the Special Report on pg 168. (Photo courtesy Meta-Software Inc)*

SPECIAL REPORT

PC-based analog simulation 168

PC-based analog-simulation software lets you create, develop, and test circuit ideas without switching on your soldering iron. To get the best results from these general-purpose design tools, you must be prepared to delve beneath the graphical user interface and understand some of their inner workings.—*Brian Kerridge, European Editor*

DESIGN FEATURES

Isolation barrier precisely passes transducer signals 189

Through the judicious use of isolation amplifiers that incorporate transformer coupling, you can design circuits that condition and amplify low-level transducer signals. Such circuits can precisely measure thermocouple, resistance-temperature-detector, and strain-gauge outputs while providing common-mode isolation in harsh environments.—*Jeffrey A Greenwald, Analog Devices Inc, Industrial Products Div*

Compression algorithms reduce digitized images to manageable size 203

Unfortunately, the number of bits in a digitized image can be huge—so large that storing or transmitting digitized images is impractical without reducing the number of bits they comprise. You can use compression algorithms to solve this problem. —*William C Warner, Consultant*

Undersampling reduces data-acquisition costs for select applications 217

Undersampling, a form of intentional aliasing, may save you from using fast, expensive track-and-hold amplifiers and A/D converters. Meeting the technique's basic requirement—prior knowledge of the input signal—enables a converter operating at a sub-Nyquist sampling rate to derive useful information from the input.—*Jeff Kirsten and Tarlton Fleming, Maxim Integrated Products*

Continued on page 7

EDN®(ISSN 0012-7515) is published 49 times a year (biweekly with 2 additional issues a month, except for February, which has 3 additional issues and July and December which have 1 additional issue) by Cahners Publishing Company, A Division of Reed Publishing USA, 275 Washington Street, Newton, MA 02158-1630. Terrence M McDermott, President; Frank Sibley, Senior Vice President/General Manager, Boston Division; Jerry D Neth, Senior Vice President/Publishing Operations; J J Walsh, Senior Vice President/Finance; Thomas J Dellamaria, Senior Vice President/Production and Manufacturing; Ralph Knupp, Vice President/Human Resources. Circulation records are maintained at Cahners Publishing Company, 44 Cook Street, Denver, CO 80206-5800. Telephone: (303) 388-4511. Second-class postage paid at Denver, CO 80206-5800 and additional mailing offices. POSTMASTER: Send address corrections to EDN® at the Denver address. EDN®copyright 1990 by Reed Publishing USA; Ronald G Segel, Chairman and Chief Executive Officer; Robert L Krakoff, President and Chief Operating Officer; William M Platt, Senior Vice President. Annual subscription rates for nonqualified people: USA, $109.95/year; Canada/Mexico, $135/year; Europe air mail, $165/year; all other nations, $165/year for surface mail and $250/year for air mail. Single copies are available for $10. Please address all subscription mail to Ellen Porter, 44 Cook Street, Denver, CO 80206-5800.

VBPA ABP



WESTCOR REDEFINES THE POWER SUPPLY ...AGAIN

WESTCOR STAKPAKS™. WORLD'S SMALLEST SINGLE OR MULTIPLE OUTPUT, FAN-COOLED SWITCHERS. THE STAKPAK: 1200 WATTS— 3.2" x 5.5" x 11.5" CASE. STAKPAK II: 600 WATTS— 1.9" x 5.5" x 12" CASE.

Westcor's compact and low profile StakPaks redefine power packaging with unprecedented power density and output flexibility. Patented megahertz module technology provides up to 6 watts/cubic inch and up to 8 isolated and fully regulated outputs (5 outputs for StakPak II) while at the same time guaranteeing high reliability and reduced time to market.

Consider these standard features:

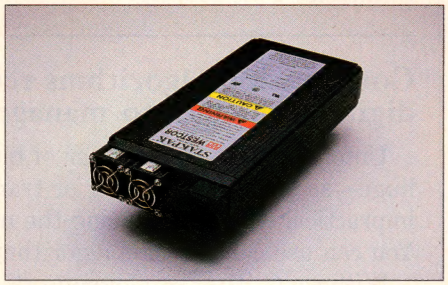
- Standard or custom outputs (2-95 VDC)
- UL, CSA, VDE (TUV) Safety Agency Approved (StakPak II in process)
- 80% Efficient, typical
- 110/220 VAC, fool-proof strapping
- Full power @ 40°C

Please contact Westcor for datasheets, pricing and additional information.

WESTCOR CORPORATION
485-100 Alberto Way
Los Gatos, CA 95032
(408) 395-7050 • FAX (408) 395-1518

Westcor is a subsidiary of VICOR CORPORATION

STAKPAK II STANDARD 600 WATT MODELS

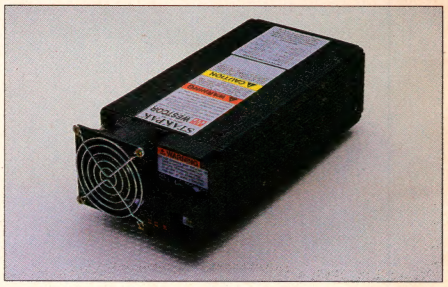


Model	Output Voltage (VDC) and Maximum Current (amperes) per Channel				
	#1	#2	#3	#4	#5
Single Output					
ST1-1401	2 @ 120				
ST1-1402	5 @ 120				
ST1-1301	12 @ 50				
ST1-1302	15 @ 40				
ST1-1303	24 @ 25				
ST1-1304	28 @ 21				
ST1-1305	48 @ 13				
Dual Output					
ST2-1401	2 @ 60	5 @ 60			
ST2-1402	5 @ 60	5 @ 60			
ST2-1403	5 @ 60	12 @ 33			
ST2-1404	12 @ 33	12 @ 33			
ST2-1405	15 @ 26	15 @ 26			
Triple Output					
ST3-1401	5 @ 60	12 @ 16	12 @ 16		
ST3-1402	5 @ 60	15 @ 13	15 @ 13		
ST3-1501	5 @ 90	12 @ 8	12 @ 8		
Quad Output					
ST4-1401	5 @ 30	12 @ 16	12 @ 16	5 @ 30	
ST4-1402	5 @ 30	15 @ 13	15 @ 13	5 @ 30	
ST4-1403	5 @ 30	12 @ 16	12 @ 16	24 @ 8	
ST4-1501	5 @ 30	15 @ 13	15 @ 13	24 @ 8	
ST4-1502	5 @ 60	12 @ 16	12 @ 8	5 @ 15	
ST4-1503	5 @ 60	15 @ 13	15 @ 7	5 @ 15	
ST4-1504	5 @ 60	12 @ 16	12 @ 8	24 @ 4	
ST4-1505	5 @ 60	15 @ 13	15 @ 7	24 @ 4	
Five Output					
ST5-1501	5 @ 30	12 @ 16	12 @ 16	5 @ 15	24 @ 4
ST5-1502	5 @ 30	15 @ 13	15 @ 13	5 @ 15	24 @ 4

Total output power may not exceed 600 watts for any model, single or multiple output. Lower power StakPak II models and many other configurations are available. Please contact the factory.

CIRCLE NO. 5

STAKPAK STANDARD 1200 WATT MODELS



Model	Output Voltage (VDC) and Maximum Current (amperes) per Channel				
	#1	#2	#3	#4	#5
Single Output					
SP1-1801	2 @ 240				
SP1-1802	5 @ 240				
SP1-1803	12 @ 100				
SP1-1604	15 @ 80				
SP1-1605	24 @ 50				
SP1-1606	28 @ 42				
SP1-1607	48 @ 25				
Dual Output					
SP2-1801	2 @ 120	5 @ 120			
SP2-1802	5 @ 120	5 @ 120			
SP2-1803	5 @ 120	12 @ 66			
SP2-1804	12 @ 66	12 @ 66			
SP2-1805	15 @ 53	15 @ 53			
Triple Output					
SP3-1801	5 @ 180	12 @ 16	12 @ 16		
SP3-1802	5 @ 150	12 @ 33	12 @ 16		
SP3-1803	5 @ 180	15 @ 13	15 @ 13		
SP3-1804	5 @ 150	15 @ 26	15 @ 13		
Quad Output					
SP4-1801	5 @ 150	12 @ 16	12 @ 16	5 @ 30	
SP4-1802	5 @ 150	15 @ 13	15 @ 13	5 @ 30	
SP4-1803	5 @ 150	12 @ 16	12 @ 16	24 @ 8	
SP4-1804	5 @ 150	15 @ 13	15 @ 13	24 @ 8	
Five Output					
SP5-1801	5 @ 120	12 @ 16	12 @ 16	5 @ 30	24 @ 8
SP5-1802	5 @ 120	15 @ 13	15 @ 13	5 @ 30	24 @ 8
Seven Output					
SP7-1801	5 @ 60	12 @ 16	12 @ 16	24 @ 8	24 @ 8
	#6	#7			
	5.2 @ 28	2 @ 30			

Total output power may not exceed 1200 watts for any model, single or multiple output. Lower power StakPak models and many other configurations are available. Please contact the factory.

Continued from page 5



***Speed may be the characteristic** that draws you to electrostatic plotters. Recent improvements in output quality and reliability might tempt you to look further (pg 91).*

Combining analog simulation techniques optimizes designs 237

Deterministic simulation helps refine your circuit design; statistical simulation can help improve the manufacturing yield. Just be sure you understand how the parameter values of your simulation models are determined. A discrete device and a monolithic device use the same model, but for accurate simulation, their parametric values will often differ.—*Lester S Sanders, Harris Corp*

HDL design methods simplify specs and boost productivity 247

Combining hardware-description languages with logic-synthesis techniques can boost your design productivity by allowing you to explore alternative design approaches.—*Karen Vahtra, Synopsys Inc*

TECHNOLOGY UPDATES

Prototyping ASICs makes design less risky 75

The time-honored art of prototyping circuit designs can also benefit ASIC designs. Programmable logic and in-circuit emulators are among the prototyping tools available.—*Richard A Quinnell, Regional Editor*

Electrostatic plotters: Fast plotters produce color and monochrome 91

The output quality and reliability of electrostatic plotters have improved, but most customers buy these raster units because of raw printing speed.—*Maury Wright, Regional Editor*

Smart-power ICs: Off-the-shelf circuits increase in popularity 113

Smart-power ICs will never completely replace the various combinations of logic, linear functions, and power that monolithic ICs and discrete power devices provide. But many smart-power ICs are now available as standard products that can satisfy an increasing range of applications.—*Dave Pryce, Associate Editor*

Continued on page 9

EDN magazine now offers Express Request, a convenient way to retrieve product information by phone. See the Reader Service Card in the front for details on how to use this free service.

Express Request

Cahners Publishing Company, A Division of Reed Publishing USA ☐ Specialized Business Magazines for Building & Construction ☐ Research ☐ Technology ☐ Electronics ☐ Computing ☐ Printing ☐ Publishing ☐ Health Care ☐ Foodservice ☐ Packaging ☐ Environmental Engineering ☐ Manufacturing ☐ Entertainment ☐ Home Furnishings ☐ and Interior Design. Specialized Consumer Magazines for Child Care ☐ Boating ☐ and Wedding Planning.

Demanding Designers Need the Best

OrCAD/SDT III

Schematic Design Tools for the PC



Ease-of-use + Power = Productivity

In today's tough design environment, good engineering tools aren't good enough. You need the best to get the job done.

OrCAD/SDT III offers the power

SDT III comes with the options you'd expect to pay extra for

- **Completeness:** A library of over 6100 parts that you can browse through in a breeze. Utilities to generate Bill-of-Materials, Electrical rules check, create custom library parts.
- **Compatibility:** Over thirty netlist formats; over 50 supported display adapters; over 50 printer drivers; a dozen plotter drivers. We conform to your system better than anyone.
- **Complexity:** 4000+ sheet design capacity for single designs. 200+ levels of hierarchy. Great support for small, simple designs to large, complex hierarchical systems.
- **Control:** SDT III gives you the ability to customize the work environment to make you more productive. This includes user definable macros, text/object sizes, sheet sizes, graphical object editor, even the colors on the screen.

OrCAD/SDT III makes it easy

The lightning fast operation saves time. The intuitive, pop-up menu displays your most likely next action. This means a short learning curve and immediate productivity.

Get our No-risk, Demo Disk

Try before you buy. Get our demonstration disk and see for yourself the solid performance SDT III has to offer.

Once you've given our demo disk a spin, you'll know one of the reasons why OrCAD is the world's leading supplier of PC based CAE tools.

All OrCAD products come complete with one full year of technical telephone support, free product updates and access to our 24 hour BBS.

OrCAD®

3175 NW Aloclek Drive
Hillsboro, Oregon 97124
(503) 690-9881

If you would like more information about this or any other OrCAD product, contact your local OrCAD representative.

AUSTRIA
Dahms Elektronik
0316/64030-0
Fax: 64030-29

BELGIUM
INEX
(02) 649.99.91
Fax:(02)649.27.92

DENMARK/ NORWAY
NordCAD
98 17 32 99
Fax: 98 17 37 41

UK
ARS Microsystems
(0276) 685005
Fax:(0276) 61524

FINLAND
Elektrotel OY
(358 0)754-3122
Fax: 754-2593

FRANCE
ALS Design
(331) 46 04.30.47
Fax: 48 25.93.60

ITALY
BRM Italiana
0117/710010
Fax: 0117/710198

ITALY
MicroData Systems
0187/966123
Fax: 0187/988322

SPAIN
Next-For S.A.
504 02 01
Fax: 504 00 69

SWEDEN
Technology Partners
(468)790 97 75
Fax: (468)16 77 86

SWITZERLAND
Logmatic AG
056/83 38 38
Fax: 056/83 38 40

W. GERMANY
Compware, GmbH
4940/81 80 74
Fax:4940/81 10 37

Call or write today for your Demo Disk!

OR8910-INTL

CIRCLE NO. 6

Continued from page 7

VP/Publisher
Peter D Coley
VP/Editor/Editorial Director
Jonathan Titus
Managing Editor
Joan Morrow
Assistant Managing Editor
Susan L Rastellini
Special Projects
Gary Legg
Home Office Editorial Staff
275 Washington St, Newton, MA 02158
(617) 964-3030
Tom Ormond, *Senior Editor*
Charles Small, *Senior Editor*
Jay Fraser, *Associate Editor*
John A Gallant, *Associate Editor*
Michael C Markowitz, *Associate Editor*
Dave Pryce, *Associate Editor*
James P Scanlan, *Associate Editor*
Julie Anne Schofield, *Associate Editor*
Dan Strassberg, *Associate Editor*
Anne Watson Swager, *Associate Editor*
Chris Terry, *Associate Editor*
Kathleen M Vejvoda, *Associate Editor*
Helen McElwee, *Senior Copy Editor*
Susan Bureau, *Copy Editor*
Christine McElvenny, *Senior Production Editor*
Gabriella A Fodor, *Production Editor*
Brian J Tobey, *Production Editor*
Editorial Field Offices
Steven H Leibson, *Senior Regional Editor*
Boulder, CO: (303) 494-2233
Doug Conner, *Regional Editor*
Atascadero, CA: (805) 461-9669
J D Mosley, *Regional Editor*
Arlington, TX: (817) 465-4961
Richard A Quinnell, *Regional Editor*
Aptos, CA: (408) 685-8028
Maury Wright, *Regional Editor*
San Diego, CA: (619) 748-6785
Brian Kerridge, *European Editor*
(603) 630782
(St Francis House, Queens Rd,
Norwich, NR1 3PN, UK)
Contributing Editors
Robert Pease, Don Powers,
Bill Travis
Editorial Coordinator
Kathy Leonard
Editorial Services
Helen Benedict, Nicky Woodlock
Art Staff
Ken Racicot, *Senior Art Director*
Chinsoo Chung, *Associate Art Director*
Cathy Madigan, *Staff Artist*
Production/Manufacturing Staff
Andrew A Jantz, *Production Supervisor*
Deborah Hodin, *Production Assistant*
Lisa K Mariano, *Production Assistant*
Michele R Weinberg, *Production Assistant*
Diane Malone, *Composition*
Director of Art Department
Joan Kelly
Norman Graf, *Associate*
VP/Production/Manufacturing
Wayne Hulitzky
Director of Production/Manufacturing
John R Sanders
Business Director
Deborah Virtue
Marketing Communications
Anne Foley, *Promotion Manager*
Pam Winch, *Promotion Assistant*

EDITORS' CHOICE 135

Simulator with tabular models

PRODUCT UPDATES

ICs for modular PC design 140
Microwave-circuit CAE tools 142
Logic-synthesis software for FPGAs 144
DSP analysis software 146
Prototyping system for control algorithms 148

DESIGN IDEAS

PLD adds hysteresis digitally 265
Regulator has common hot lead 266
PLD decodes FM data 268
Circuits kill storage delays 270
PLD processes pixels pronto 272
Feedback and Amplification 274

EDITORIAL 69

Companies still don't communicate well with customers—who are just the people they must help to survive.

NEW PRODUCTS

CAE & Software Development Tools 279
Components & Power Supplies 286
Computers & Peripherals 294
Integrated Circuits 304
Test & Measurement Instruments 312

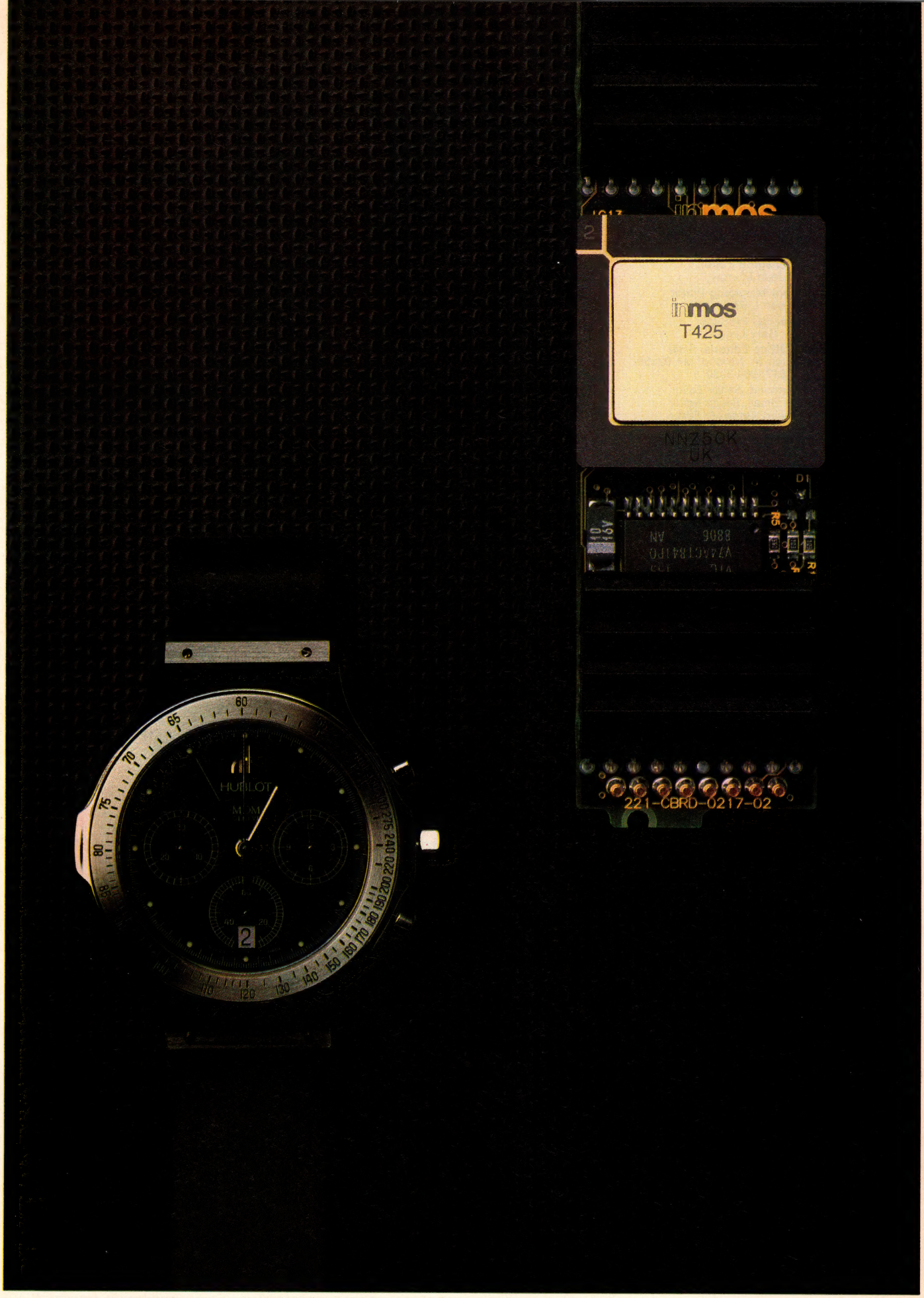
PROFESSIONAL ISSUES 326

From financial flop to Fortune 500

George Hatsopoulos built Thermo Electron on an invention that never sold.—*Jay Fraser, Associate Editor*

DEPARTMENTS

News Breaks 21
Signals & Noise 47
Calendar 56
Literature 319
Book Review 324
Career Opportunities 340
EDN's International Advertisers Index 345



32 bit microprocessor, 1M byte DRAM, 25 MIPS.

HOW CAN THIS 32 BIT MICROPROCESSOR GET YOU TO MARKET FIRST?

This INMOS transputer module is a complete system comprising a 32 bit transputer and 1M byte of DRAM on a 4 signal layer board.

The simplicity of its design means you can develop products quickly – and be confident that your board will be working first time.

In short, you can use it to get to market before your competitors.

The T425 gives 25 MIPS peak performance, has a 760 nS response to interrupts and runs off a single 5 Mhz clock.

Four 2.4M bytes/sec serial links provide communication with peripherals such as A/D converters or display drivers.

And, should you need to make modifications, or add more processing power to a design, the serial links connect directly to other transputer systems. This unique multi-processing capability means that software can be recompiled easily to give true scalable performance.

The transputer family is supported by a complete range of hardware and software development tools for PC, VAX and SUN hosts. These include compilers for C, FORTRAN, Pascal, occam and ADA, software simulators and debuggers. Transputers are also qualified to Mil STD 883C.

If you'd like to get to market first, our comprehensive 'Transputer Guide' will tell you all you need to know. Ring the number below for your FREE COPY . . .

inmos®
THE TRANSPUTER FAMILY

Multiprocessing Made Simple

SGS-THOMSON MICROELECTRONICS INMOS is a member of the SGS-THOMSON Microelectronics Group · SGS-THOMSON Microelectronics · UK Tel: (0628) 890800 · Sweden Tel: (8) 7939220 Germany Tel: (89) 46 00 60 · France Tel: (1) 47 40 75 75 · Italy Tel: (2) 89213 1 · USA Tel: (602) 867 6259 · Singapore Tel: (65) 482 14 11 · Japan Tel: (3) 280 4125

A GRAPHIC EXAMPLE OF WHY APPLE CHOSE THE AMD 29K.

When you set out to design the most advanced graphics system technology, you have to search for the most innovative microprocessor you can find.

That's why Apple® called AMD. When it came to designing their new Macintosh® graphics accelerator board* they needed AMD's 29K™ RISC microprocessor. At 23 MIPS, only the 29K can boost the speed of 32-bit QuickDraw® graphics routines from five to thirty times. More than enough for photo-realistic images. And for the first time ever, true 24-bit color graphics can be displayed at even faster than monochrome speeds.

You can have the same kind of performance with the 29K. And you don't have to wait to get started. Or finished. AMD and over 40 Fusion29K™ partners already have complete hardware and software development tools. Such as the HP® emulator, Microtec® Research and Intermetrics™ cross compilers and debuggers.

Drop us a line to find out everything you need to know. And don't take any chances when it comes to your RISC design.

Advanced Micro Devices

CIRCLE NO. 9

29K and Fusion29K are trademarks of Advanced Micro Devices, Inc. Where indicated, product and company names are trademarks/registered trademarks of their respective holders.

For more information write "29K" on your letterhead and mail to: (In Europe) AMD Mail Operations, P. O. Box 4, Westbury-on-Trym, Bristol BS9 3DS United Kingdom (In Asia) Advanced Micro Devices Far East Ltd., Rm. 1201-2 Harcourt House, 39 Gloucester Road, Hong Kong, Attn: Andrew Ng. (In Japan) Advanced Micro Devices Japan Ltd., Shinjuku Kokusai Bldg., 6-6-2 Nishi-Shinjuku, Shinjuku-ku, Tokyo 160, Japan.

Bruxelles (02-2) 771 91 42 • Geneva (02) 2880025 • Hanover area (0511) 73 60 85 • Hong Kong (5) 8654525 • London area (0483) 740440 • Manchester area (0925) 828008 • Milano (02) 3533241 • München (089) 41 14-0 • Osaka (06) 243-3250 • Paris (1) 49 75 10 10 • Seoul (02) 784-7598 • Singapore (65) 348 1188 • Stockholm (08) 733 03 50 • Stuttgart (0711) 62 33 77 • Taiwan (02) 7213393 • Tokyo (03) 345-8241 • Latin America, Fort Lauderdale, Florida/U.S.A Tel: (305) 484-8600 Tlx: (510) 955-4261 amd ftl

*Macintosh Display Card 8•24 GC

©1990 Advanced Micro Devices, Inc.

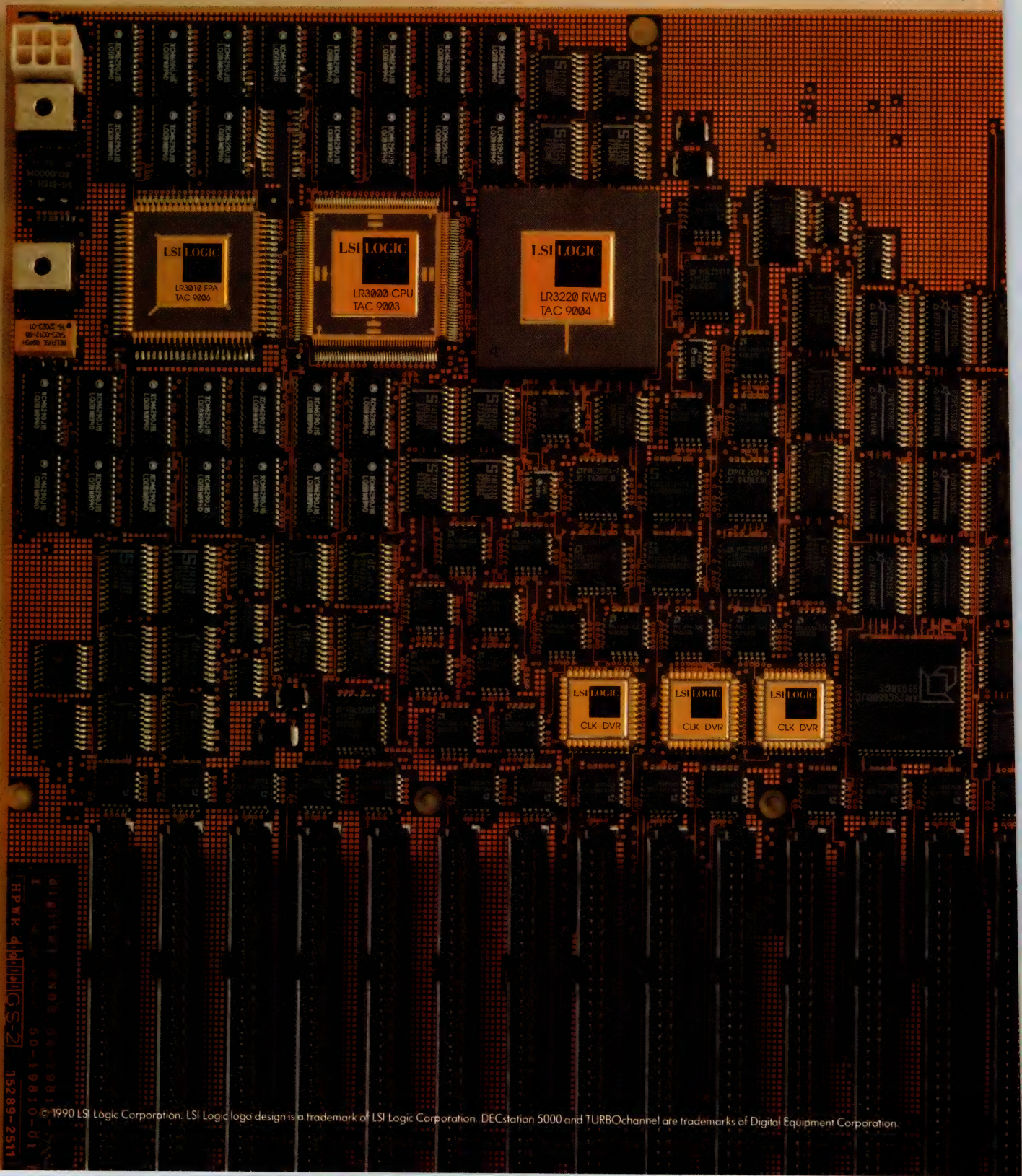


HOW A STRATEGIC PARTNERSHIP WROTE A NEW CHAPTER ON SYSTEM PERFORMANCE:

DECstation 5000 AND LSI LOGIC.

Achieving 24.2 MIPS at 25 MHz was no small task. Even for Digital.

So they designed-in LSI Logic's unique read-write buffer and MIPS-based chipset that optimized the processing power of the LR3000 CPU. And consolidated the read-write buffer functions of 17 chips into a single chip. Putting far more performance into far less real estate. And making the new DECstation 5000 workstation a



© 1990 LSI Logic Corporation. LSI Logic logo design is a trademark of LSI Logic Corporation. DECstation 5000 and TURBOchannel are trademarks of Digital Equipment Corporation.

reality. In less than 11 months.

LSI's proprietary LR3220 read-write buffer performs memory write operations at the CPU clock rate, practically eliminating the bottleneck between the CPU and main memory. Boosting the processing power of the DECstation 5000 workstation to the limits of the price performance curve. A novel idea that delivers 120 Mbytes of main memory, dazzling high-end graphics and the new TURBOchannel I/O interconnect to the desktop, for under $15,000.

If you'd like to write the next chapter in the workstation wars, call us. We'll help you quickly turn your technology into a best seller.

LSI LOGIC

ACROSS THE BOARD



According to Tom Furlong, Manager of Digital Equipment Corporation's RISC Workstation Group, "The level of performance achieved on the DECstation 5000 workstation simply wouldn't have been possible without LSI's ASIC methodology and their MIPS microprocessor expertise."

For the whole story call 408.433.7556, or write for a free white paper, "Writing a new chapter in workstation performance: DECstation 5000," LSI Logic, 1551 McCarthy Blvd, MS D102, Milpitas, CA 95035.

CIRCLE NO. 10

SAMSUNG NOW

THANKS TO OUR HIGH
OF A NEW DAY IN USES

Until now, there's been no volume supplier of the leading-edge 256K CMOS EEPROM, so supplies have been short.

Samsung has changed all that. We're producing extremely high volumes, and as you can see, all kinds of new ways to use the part are turning up.

SAMSUNG'S CMOS EEPROMs

Part Number	*Organization*	*Type*	*Fastest Speed*	*Features*
KM28C256	32Kx8	Parallel	150	*Data polling, toggle bit, 64 page mode*
KM28C64	8Kx8	Parallel	200	*Data polling, 32 page mode*
KM28C65	8Kx8	Parallel	200	*Data polling, ready/busy*
KM28C16	2Kx8	Parallel	150	*Data polling, 32 page mode*
KM28C17	2Kx8	Parallel	150	*Data polling, ready/busy*
KM93C06	16x16	Serial	—	—
KM93C07	16x16	Serial	—	*Write protect, self-timed programming*
KM93C46	64x16	Serial	—	*Write protect, self-timed programming*

Industrial grade versions of all products are available. All parts offered in both DIP and PLCC (SOIC for serial). 256K Industrial available Q4 1990, other parts all available now.

Large-memory cellular phones, and . . . well, we're sure you'll think of *many* other interesting things to do with them.

Also new from Samsung are parts proven for industrial temperature ranges, which means you can use them in robotics, automotive



VOLUMES, IT'S THE DAWN FOR 256K EEPROMs.



applications, industrial control and related areas.

Our 256K parts boast a fast, 5 millisecond/page write time. This gives you an effective byte write time (including erase cycle) of just 78 microseconds. And the entire chip can be rewritten in only 2.5 seconds.

What all these things represent is a broad-based commitment at Samsung to EEPROMs. We also offer CMOS 64K and 16K parts, a variety of serial EEPROMs, and forthcoming higher-density serial parts.

Surface mount packaging is available across the entire line.

Request a comprehensive Samsung EEPROM Quality Kit, including samples, by calling 1-800-669-5400 or 408-954-7229 now. Or write to EEPROM Marketing, Samsung Semiconductor, 3725 No. First St., San Jose, CA 95134.

And start planning your *own* new uses.

SAMSUNG Semiconductor

© Samsung Semiconductor, Inc., 1990.

CIRCLE NO. 11



Even though our products have been to Jupiter and beyond, you can still find them out in your garage.



Whether it's one of the switches in your automobile, or connectors used in space exploration, you'll find the products of ITT ElectroMechanical Components Worldwide everywhere.

With seventy-five years of leadership in the electronics industry, ITT EMC Worldwide is one of the world's leading suppliers of electronic components. You know us as ITT Cannon, Schadow, Jeanrenaud, Pomona Electronics, MTI and Sealectro. With manufacturing facilities, engineering centers and customer service representatives in virtually every part of the world.

Our history is one of innovation, and ever-increasing capabilities. That's precisely why many of our products go on to become industry standards.

At ITT EMC Worldwide, we build reliability into every product we sell. That's why you'll find us in everything from appliances to satellites.

Our philosophy of "building in" quality control and testing means that you get the best possible product, every time. What's more, ITT EMC Worldwide manufactures and sells quality test accessories, to assist you in building a quality product as well.

No matter where in the world you are, chances are we have an office nearby. So drop us a line today. Even though we're an international company, we may be closer than you think.

1851 East Deere Avenue, Post Office Box 35000
Santa Ana, CA 92705-5300
Phone: (714) 261-5300 Fax: (714) 757-8324/8301
Telex: (714) 655358

ITT ElectroMechanical Components Worldwide
Discover our strengths.

CIRCLE NO. 12

Don't miss the most valuable A/D Converter Seminar of 1990

8 to 24 bits **dc to 4 MHz**

Delta Sigma ADCs
Self-Calibrating ADCs
Error Budgeting
Anti-Aliasing
Grounding
Board Layout
Debugging
Test Techniques
Live Demonstrations
Latest Data Sheets
Weigh Scales
Medical
Digital Audio
Industrial Control
Seismic
Image Processing
Military
Instrumentation
Space
Modems

AL	Huntsville	Nov 28	CO	Colorado Springs	Aug 21	MI	Grand Rapids	Jul 30	OK	Tulsa	Dec 13
ALB	Calgary	Aug 23		Denver	Aug 22	MN	Minneapolis	Sep 13	ONT	Ottawa	Aug 2
	Edmonton	Aug 24	CT	Waterbury	Oct 2	MO	Kansas City	Dec 5		Toronto	Aug 1
AZ	Phoenix	Sep 11	FL	Clearwater	Oct 11		St. Louis	Dec 4	OR	Portland	Sep 7
	Tucson	Sep 12		Ft. Lauderdale	Oct 8	NC	Charlotte	Jul 25	PA	Ft. Washington	Aug 16
BC	Vancouver	Sep 5		Melbourne	Oct 9		Raleigh	Jul 24		Pittsburgh	Aug 30
CA	Los Angeles	Jul 11		Orlando	Oct 10	NH	Nashua	Oct 4	QBC	Montreal	Aug 3
	Sacramento	Jul 20	GA	Atlanta	Nov 29	NJ	Cherry Hill	Aug 15	TN	Knoxville	Nov 30
	San Diego	Oct 16	IA	Cedar Rapids	Dec 6		Edison	Aug 14	TX	Austin	Dec 10
	San Fernando	Jul 9	IL	Arlington Hts.	Nov 15		Saddlebrook	Aug 13		Dallas	Dec 12
	San Fernando	Oct 18		Oakbrook	Nov 16	NM	Albuquerque	Sep 10		Houston	Dec 11
	San Gabriel	Jul 12	IN	Fort Wayne	Oct 26	NY	Buffalo	Aug 7	UT	Salt Lake City	Dec 7
	San Jose	Jul 18		Indianapolis	Oct 24		Long Island	Aug 10	VA	Falls Church	Jul 26
	San Jose	Oct 19		Kokomo	Oct 25		Rochester	Aug 8	WA	Seattle	Sep 6
	Santa Barbara	Jul 9	MA	Andover	Oct 4		Syracuse	Aug 9	WI	Madison	Nov 14
	Oakland	Jul 19		Boxborough	Oct 3	OH	Cincinnati	Oct 23		Milwaukee	Nov 13
	Orange County	Jul 10		Newton	Oct 3		Cleveland	Aug 29			
	Orange County	Oct 17	MD	Baltimore	Jul 27		Columbus	Aug 28			
	Palo Alto	Jul 17	MI	Detroit	Jul 31		Dayton	Aug 27			

CALL CRYSTAL SEMICONDUCTOR TODAY FOR RESERVATIONS

1-800-888-5016 CRYSTAL **512-445-7222**

CIRCLE NO. 13

NEWS BREAKS

EDITED BY JULIE ANNE SCHOFIELD

DRIVE HANDLES WORM AND REWRITABLE OPTICAL MEDIA

The 5¼-in. LD 520 optical disk drive from Laser Magnetic Storage (Colorado Springs, CO, (719) 593-7900) works with both WORM (write once, read many) and rewritable optical media. The drive is compatible with drives from Pioneer and Optimem. The vendor offers the drive in desktop, cabinet, and internal models. You can expect the company to sell subsystems for Apple- and IBM PC-compatible computers. The drive will be available in September for $2395 in OEM quantities. WORM media currently cost about $113 per disk; expect rewritable media to cost less than $200.
—Maury Wright

4-CHANNEL ANALOG-OUTPUT BOARD HAS 13-BIT RESOLUTION

The $800 AOM5 from Keithley DAC (Cleveland, OH, (216) 248-0400) offers twice the resolution and number of channels of conventional analog-output cards. The board uses one polarity bit to double its 12 data bits of resolution to 250 μV/bit. The full-scale output ranges are ±10, ±5, ±2, and ±1V. You can use the board with IBM PC/AT-compatible computers and the manufacturer's Series 500 hardware and software. The board can accept data at 16M bytes/sec, and each channel has a 5-μsec settling time. Achievable output performance with an IBM PC/AT and the company's software is 50k samples/sec.—J D Mosley

DESIGN TOOLS LET YOU CUSTOMIZE ANALOG CELLS IN-HOUSE

The Mixed-Signal Design Solution (MSDS) from Gould/AMI (Pocatello, ID, (208) 234-6679) will let system designers specify the parameters of the analog portions of their circuit on their own Sun or Apollo workstations. The company's proprietary software then converts standard analog cells to behavioral models that match your specifications. The analog building-block library includes a S/H buffer, a variable gain block, oscillators, a band-gap reference, buffered I/O pads, and assorted filters.

The software package also includes the company's digital cell library, schematic-capture tools, proprietary design-critiquer and specification-advisor software, and an interface to the Saber/CADAT simulator developed jointly by Analogy (Beaverton, OR, (503) 626-9700) and the HHB division of Racal-Redac (Mahwah, NJ, (201) 848-8000). This simulator can model an ASIC design's analog and digital functions at the transistor, behavioral, and system levels. The entire $50,000 software package, which includes the simulator, will be available in January 1991. At that time, the company will also provide additional analog building blocks and test-program-generator software.—Anne Watson Swager

CIRCUITRY LOWERS NOISE IN 5-NSEC PLDs

Texas Instruments (Dallas, TX, (800) 232-3200, ext 700) has produced a family of 5-nsec bipolar PLDs with noise characteristics 20% lower than those of standard 7-and 10-nsec devices. These devices achieve their speed levels because they have three delay elements from input to output instead of the five typically found in conventional TTL-based PLD designs. The devices employ temperature-compensated voltage regulators to minimize drops in the chip's internal V_{CC}, which can result when many outputs switch simultaneously. The TIBPAL16L8 sells for $8.80 (1000) in a 20-pin DIP; the TIBPAL20L8 sells for $11 (1000) in a 24-pin DIP.—J D Mosley

NEWS BREAKS

CFI WILL DEMONSTRATE FIRST PRODUCT AT DAC

You can see the first glimmerings of cooperative effort among CAE tool vendors next week at the Design Automation Conference (DAC) in Orlando, FL, June 24 to 28. CAD Framework Initiative Inc's (CFI, Boulder, CO, (303) 530-4562) booth will demonstrate a prototype of the group's procedural interface. This interface is a common format and access protocol that lets various CAE tools and other programs exchange net-list information. The demonstration involves approximately 30 software programs from about 20 vendors running on five different workstations. An Ethernet link ties the workstations together, and the tools running on the various workstations interact with each other through remote procedure calls. CFI already has more than 50 corporate members, and membership is open to all interested companies. At DAC, CFI will sponsor a session on June 26 from 6 to 7:30 pm in room 20D of the Orange County Convention Center to discuss the demonstration project. —Steven H Leibson

LOGIC-SYNTHESIS SOFTWARE SUPPORTS PLDs AND GATE ARRAYS

Bytek's (Boca Raton, FL, (407) 994-3520) Logisoft logic-synthesis software supports the company's line of PROM and PLD programmers. You can enter data into the software package via Boolean equations, function tables, and CAE schematic-capture packages. A PLD database module accepts your finished design and provides a list of PLDs that you could use to implement the design. The company also offers a software module that lets you verify a design, and a module that detects logical inconsistencies in your work. An IBM PC-compatible version of the software costs $1495.—Maury Wright

INTEL COFOUNDER ROBERT N NOYCE DEAD AT 62

Robert N Noyce, a cofounder of Intel died at age 62 in Austin, TX, on June 3, 1990. Perhaps best known as the head of Intel, a position he held for many years, electrical engineers also knew Noyce as the coinventor—with Jack Kilby—of the integrated circuit. Noyce's considerable technical achievements led to the development of the dynamic random-access memory (DRAM) and the microprocessor at Intel, and he was one of the electronic industry's most prominent spokesmen. He was a founder of the Semiconductor Industry Association and was the president of Sematech at the time he died. After completing his doctorate in physics at the Massachusetts Institute of Technology in 1953, Noyce worked at the Philco Corp and then at Shockley Semiconductor. He left Shockley to cofound Fairchild Semiconductor, and Noyce and Gordon Moore founded Intel in 1968.—Jon Titus

INTERFACE FEEDS NEURAL NETWORK REAL-TIME DATA

Science Applications International Corp (San Diego, CA, (619) 546-6000) offers an IBM PC/AT-compatible hardware interface that can provide real-time data to a neural network. The DAI 1016 operates with Data Translation's (Marlborough, MA, (508) 481-3700) DT Connect data-acquisition peripherals and transfers data at 20M bytes/sec. The interface supports the company's Delta II floating-point processor and suits such applications as robotics, sensor processing, imaging systems, automatic inspection, waveform analysis, and radar signal processing. You can connect as many as five of the $2000 DAI 1016 units to each Delta II in a system.—Maury Wright

PLDs 125 MHz State Machine, MAX™ and 7C330 family.



Check out our 125 MHz state machine. Our 128 Macrocell MAX part. Or any of 24 varieties in between.

Fastest ECL



Programmable Logic with 3.5 ns performance. SRAM to 3 ns. 14 ways to speed up your system.

SPARC 40 MHz Chipset



Our 29 MIPS SPARC chipset gives you the performance you want, and the standard software you need.

BiCMOS SRAM



0.8 micron SRAM with 12 ns performance is the world's fastest 64K TTL. Here are seven of the fastest parts in memory.

SRAM Modules



High speed 32-bit SRAM organized in the word-widths you need to save on space and time. 30 flavors, plus custom.

You'll want to keep tabs on these.

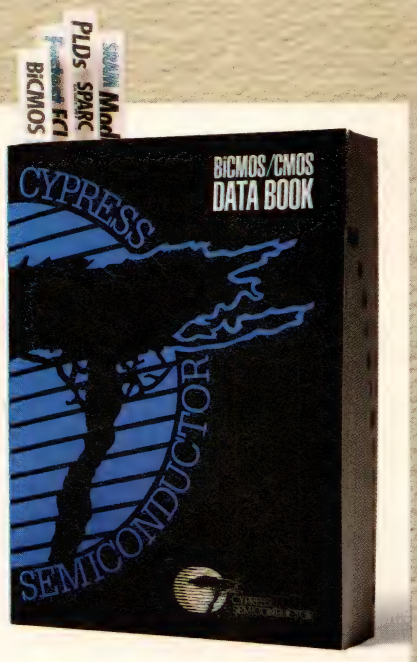
To make that easier, we'll send you our new Data Book if you call the toll-free number below.

You'll get 1344 pages of hard data on our high performance parts, support tools, quality programs, military programs, and packaging options.

You'll get thorough descriptions of all our SRAMs, PROMs, EPLDs, FIFOs, LOGIC, SPARC Microprocessors, SRAM Modules, BiCMOS, and ECL parts.

An idea book for high performance designers, our 1990 Data Book can be yours for a fast, free call.

Data Book Hotline:
1-800-952-6300.*
Ask for Dept. C4G.



CYPRESS SEMICONDUCTOR

*1-(800) 387-7599 in Canada. (32) 2-672-2220 in Europe. ©1990 Cypress Semiconductor, 3901 North First Street, San Jose, CA 95134. Phone (408) 943-2600, Telex: 821032 CYPRESS SNJ UD, TWX: 910-997-0753. MAX is a trademark of Altera Corporation.

NEWS BREAKS

EXPERIMENTS INDICATE THE ADVANTAGES OF GUIs

The ballyhoo lavished on graphical user interfaces (GUIs) leaves many software developers and computer users wondering if the noise is actually warranted. Zenith Data Systems (Mt Prospect, IL, (800) 553-0331) and Microsoft Corp (Redmond, WA, (206) 882-8080) hired an independent research firm to conduct experiments that compared users' performance while using character-based and graphical user interfaces. The study's results indicate that GUI users work faster, complete more tasks accurately, and are more productive than users of character-based interfaces. The study also found that GUI users experience less frustration and fatigue, learn new application programs more easily, and learn more of an application program's capabilities. Numerical data from the study backs these claims.

On the average, novice GUI users completed 42% more tasks than novice users of character-based interfaces. Experienced GUI users correctly completed 91% of their exercises vs a 74% score for character-based interface users. In the same experiment, 69% of the experienced GUI users completed all of their tasks but only 17% of the experienced non-GUI users completed all tasks. A single study of human responses proves little, but the results certainly indicate that GUIs help users get more out of their computers.—Steven H Leibson

SCSI AND IDE WINCHESTERS STORE 330M TO 425M BYTES

The two newest members of Quantum Corp's (Milpitas, CA, (408) 432-1100) 3½-in. ProDrive family store 336M and 425M bytes. The model 330 and 425 Winchester disk drives come with your choice of SCSI or IDE (Integrated Drive Electronics) interfaces. The drives include a cache, offer an average seek time of 14 msec (12 msec on reads), and have a 2-year warranty. The IDE drives transfer data as fast as 4M bytes/sec using programmed I/O. The SCSI drives transfer data at a maximum of 4M bytes/sec in asynchronous mode and 5M bytes/sec in a synchronous mode. Both types of drives feature a maximum raw data rate of 22M bps, an MTBF of 15,000 hours, and a nonrecoverable error rate of 1 in 10^{14} bits. Expect July shipments of evaluation units at prices of $1195 for the Model 330 and $1495 for the Model 425.
—Maury Wright

IN-CIRCUIT EMULATOR SUPPORTS i960CA PROCESSOR

Designers working with Intel's i960CA processor will soon have an in-circuit emulator to add to their tool kits. Step Engineering (Sunnyvale, CA, (408) 733-7837) has developed a PC-based instrument that lets you monitor and control the processor's operation at speeds as great as 25 MHz. The Express960 works in conjunction with a software debugger to couple real-time tracing with source-level decoding. You can use Microtec Research's Xray or Intel's family of debuggers with the emulator.

The instrument has a 160-bit × 8k-word trace buffer, which lets you capture 32 bits of external data as well as the states of the processor's external buses. To keep track of the processor's internal instruction cache, the instrument provides a state machine and shadow memory that maintains a copy of cached instructions. Built-in debugging features include memory tests and controlled loops that let you observe timing with an oscilloscope. The instrument costs $13,500 and is available 60 days ARO.—Richard A Quinnell

RUGGED SOLUTIONS TO TOUGH DESIGN PROBLEMS.



Portable data products from Datakey are meeting the needs of electronic OEM design engineers in a wide range of commercial and military applications. They can help you:

- ☐ Save valuable system space
- ☐ Reduce system power requirements
- ☐ Cut the cost of memory/feature expansion
- ☐ Improve system and facility security
- ☐ Speed data transfer, make data handling more convenient
- ☐ Make ROM upgrades quicker, easier
- ☐ Simplify system design and manufacturability
- ☐ Ruggedize your system or I/O device
- ☐ Reduce repetitive data input
- ☐ Differentiate your product in the marketplace

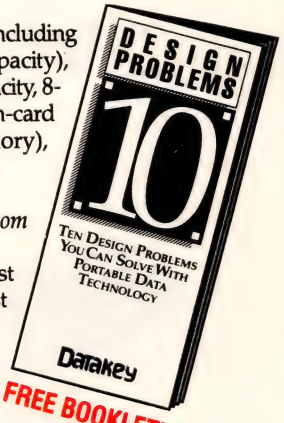
These versatile devices withstand rough handling and retain your data even when exposed to dust, dirt, moisture, magnetic fields, and other environmental hazards.

We've developed a whole array of solutions for tough portable data applications — including the access device for the U.S. government's secure phone system. Hundreds of thousands of these devices are in use today.

Choose from our standard products, including *Serial Memory Keys* (1K, 2K, or 4Kbit capacity), *Parallel Memory Keys* (16K to 512Kbit capacity, 8-bit word length), *Memory Cards* (chip-on-card or edge-connect with embedded memory), *Low-Cost Personal ID and Memory Tokens, Mechanical/Electronic Keys*, and more.

We also design and manufacture *custom* portable data devices.

So, call today for our free booklet. It just may help you solve some of the toughest design problems around. *Yours.*



FREE BOOKLET!

Call 1-800-328-8828
Need it fast? We'll fax it.

DataKey®
Advanced Solutions in Portable Data Technology.™

Datakey, Inc. • 407 West Travelers Trail, Minneapolis, MN 55337 U.S.A. • Phone (612) 890-6850 • Fax (612) 890-2726
United Kingdom: 44 730 816502 • **West Germany:** 49-06173-68872 • **Belgium:** 32 3 325 19 10 • **Netherlands:** 023-31 91 84

CIRCLE NO. 14

THE WORLD'S LARGEST MANUFACTURER OF POWER SPLITTERS/ COMBINERS



2 KHz to 8 GHz *from* $10.45

With over 300 models, from 2-way to 48-way, 0°, 90° and 180°, a variety of pin and connector packages, 50 and 75 ohm, covering 2KHz to 8000MHz, Mini-Circuits offers the world's largest selection of off-the-shelf power splitter/combiners. So why compromise your systems design when you can select the power splitter/combiner that closely matches your specific package and frequency band requirements at lowest cost and with immediate delivery.

And we will handle your "special" needs, such as wider bandwidth, higher isolation, intermixed connectors, etc. courteously with rapid turnaround time.

Of course, all units come with our one-year guarantee.

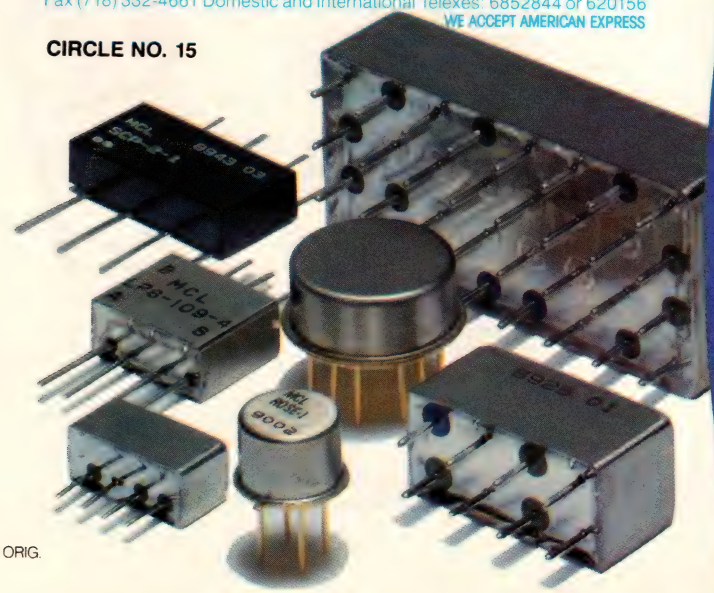
For detailed specs and performance data, refer to the MicroWaves Product Directory, EEM or Mini-Circuits RF/IF Signal Processing Handbook, Vol. II. Or contact us for our free 68-page RF/IF Signal Processing Guide.

finding new ways ...
setting higher standards

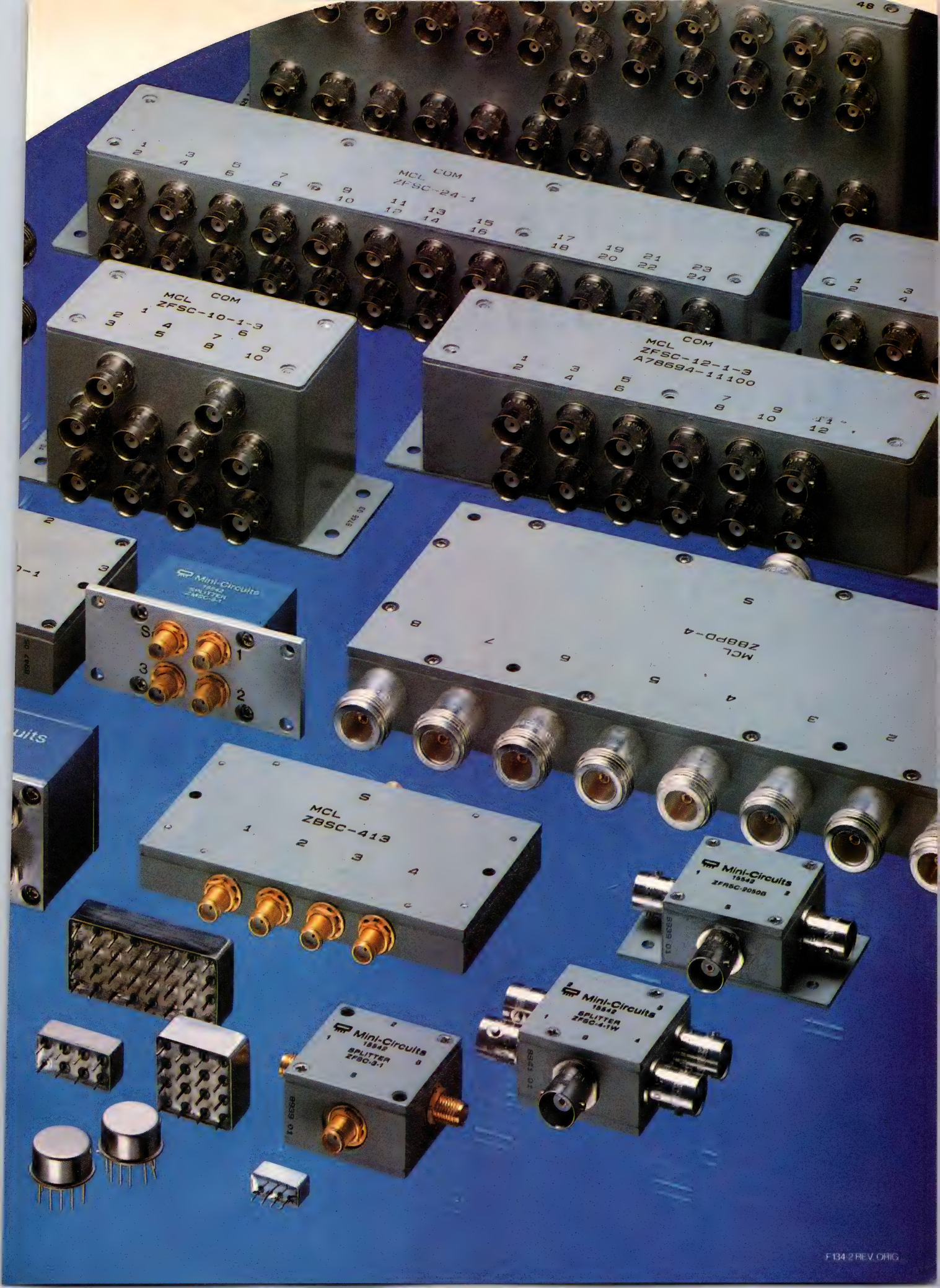
Mini-Circuits

A Division of Scientific Components Corporation
P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500
Fax (718) 332-4661 Domestic and International Telexes: 6852844 or 620156
WE ACCEPT AMERICAN EXPRESS

CIRCLE NO. 15



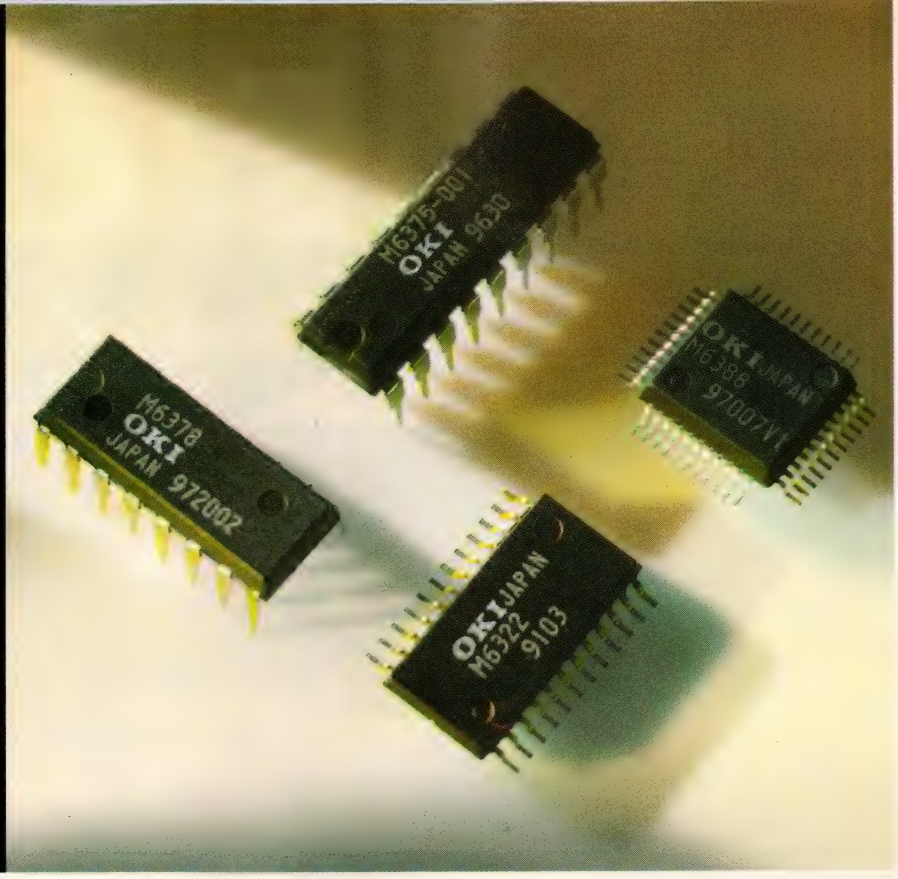
F134-1 REV. ORIG.


MCL COM
ZFSC-24-1
MCL COM
ZFSC-10-1-3
MCL COM
ZFSC-12-1-3
A78594-11100
MCL
ZBSC-413
Mini-Circuits
SPLITTER
ZFSC-2-1
Mini-Circuits
SPLITTER
ZFSC-4-1W
Mini-Circuits
ZFRSC-2050B

These speech synthesizers can be difficult to work with...



these aren't.



Tired of working with speech synthesizers that squawk or screech or sound like tinny talking toys? Do your high-tech applications demand high-quality sound reproduction?

If so, you need to sound out Oki's easy-to-use speech synthesizers. The superior quality of our chips quickly demonstrates that it's one thing to imitate sound. It's another to synthesize it.

Our state-of-the-art synthesizers offer the high integration and realistic sound you expect, with features like these:

- on-chip low pass filter
- on-chip 12-bit D/A converter
- 4-bit ADPCM algorithm for better than FM signal-to-noise ratio

And we have the range of products to meet your varied applications: Three masked ROM chips with 10- to 40-second message options. A ROMless development chip. A one-time programmable chip. A real-time pitch control chip. And a solid-state recorder.

If you like the sound of our offerings, you'll love the sound of our chips. Order a demo board from Oki today. And you'll design us in tomorrow.

So. Calif.
(Irvine)
714/752-1843
(Sherman Oaks)
818/990-3394
No. Calif.
(San Jose)
408/244-9666
Boca Raton, FL
407/394-6099
Atlanta, GA
(Norcross)
404/448-7111
Chicago, IL
(Rolling Meadows)
708/870-1400
Boston, MA
(Stoneham)
617/279-0293
Detroit, MI
(Livonia)
313/464-7200
New York, NY
(Poughkeepsie)
914/473-8044
Philadelphia, PA
(Horsham)
215/674-9511
Dallas, TX
(Richardson)
214/690-6868

OKI Semiconductor

Quality that speaks for itself.

CIRCLE NO. 16

FLUKE AND PHILIPS – THE GLOBAL ALLIANCE IN TEST & MEASUREMENT

FLUKE®

PHILIPS

PHILIPS



Power packed DSO choices upto 250 MS/s.

20 MS/s - 60 MHz

100 MS/s - 60 MHz

100 MS/s - 100 MHz

250 MS/s - 60 MHz

250 MS/s - 100 MHz

Now, Philips offers you more power packed choices in mid-frequency digital storage oscilloscopes. With a new range of five models, from entry-level to advanced.

Each one is a breakthrough in performance and ease of operation. And each one is priced to give you unexpected economy.

Operation is simple and intuitive - just like a conventional analog instrument. With full analog functionality for real-time signal display and measurements.

But just select 'digital memory' to get powerful DSO facilities. Letting you capture, compare and analyze both single-shot and repetitive signals.

So check the features and performance of these power packed instruments. And see for yourself why they add up to unbeatable value in digital storage.

■ ***PM 3335*** *20 MS/s sampling rate, large 8 K deep memory, 60 MHz analog bandwidth, full cursor measurements, combined GPIB/IEEE-488 - RS232-C interface option.*

■ ***PM 3350A*** *100 MS/s sampling simultaneously on both channels, 60 MHz analog bandwidth, 4 memory registers, fast-action 'intelligent cursors', Digitally Delayed Timebase, GPIB/IEEE-488 or RS232-C interface options.*

■ ***PM 3365A*** *100 MS/s sampling simultaneously on both channels, plus repetitive sampling at up to 100 MHz, 100 MHz analog bandwidth, 4 memory registers, extra signal-processing modes, Digitally Delayed Timebase, GPIB/IEEE-488 or RS232-C interface options.*

■ ***PM 3355*** *Fast 250 MS/s sampling simultaneously on both channels, 60 MHz analog bandwidth, 4 memory registers, fast-action 'intelligent cursors', Digitally Delayed Timebase, GPIB/IEEE-488 or RS232-C interface options.*

■ ***PM 3375*** *Fast 250 MS/s sampling simultaneously on both channels, plus repetitive sampling at up to 100 MHz, 100 MHz analog bandwidth, 4 memory registers, fast-action 'intelligent cursors', Digitally Delayed Timebase, GPIB/IEEE-488 or RS232-C interface options.*

To find out more about the power packed choices in mid-frequency DSOs, just contact your local sales office:
Austria *(0222) 60101-1772,* ***Belgium*** *(02) 5256692/94,* ***Denmark*** *(31) 572222,* ***Finland*** *(0) 5026371,* ***France*** *(1) 49428080,* ***Germany*** *(561) 501466,* ***Great Britain*** *(923) 240511,* ***Ireland*** *(61) 330333,* ***Italy*** *(039) 3635240/8/9,* ***Netherlands*** *(13)390112,* ***Norway*** *(2) 741010,* ***Portugal*** *(1) 683121,* ***Spain*** *(1) 4042200,* ***Sweden*** *(8) 7031000,* ***Switzerland*** *(1) 4882390.*
For countries not listed, write to: Philips I&E, T&M Department, Building TQ III-1, 5600 MD Eindhoven, The Netherlands.

ADVANCED TECHNOLOGY MADE TO MEASURE

PHILIPS

PHILIPS

PACESETTERS--

UMC HEAT

THE NEW 386 HIGH-END AT CHIP SET FROM UMC



A ULSI PLANT TO SUPPLY YOU,
A EUROPE OFFSHORE BRANCH
TO SERVE YOU.

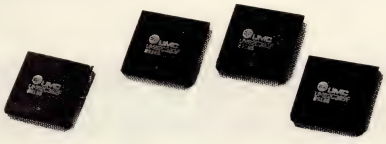
COMPARE THESE FEATURES:

High Integration, Flexibility, Adaptable, Cache Control

These stunningly versatile chip set that can be designed with either page mode (20/25MHz, 80386 AT) or cache mode (25MHz, 80386 AT) depending upon customer requirements. Additionally, it can be designed in a baby- sized AT board , requiring only 10 TTL— and without PAL.

UMC is committed to providing its customers with a TOTAL SOLUTION. That's why it sets the pace providing Cache Controller through chip sets.

By the way, our services are now closer than you may have realized. Our European offshore branch is now established and operating in Amsterdam, Holland . Contact us TODAY .You'll be glad you did.



UMC UNITED MICROELECTRONICS CORPORATION

EUROPE HEADQUARTERS:

UNITED MICROELECTRONICS B.V. TEL:020-970-766 FAX:020-977-826 TLX:11677 UMC NL

AUSTRIA
LEITGEB, KG
TEL: 43-47-624022
TLX: 47-48191 DLEIA
FAX: 43-4762-5451

BELGIUM
INELCO BELGIUM SA/NV
TEL: 32-2-216-0160
TLX: 64475 INELCO B
FAX: 32-2-2166-6150

DENMARK
AEG-DANSK AKTIESELSKAB
TEL: 320-22160
TLX: 33122 ELAEG DK
FAX: 45-2-64-8522

FRANCE
ASIA MOS
TEL: 47601255
TLX: OMT 613890 F
FAX: 33-147601582

GERMANY
DISCOMP ELEKTRONIK GmbH
FAX: 49-7161-57101
TEL: 49-7161-57175

ENDRICH BAUELEMENT E VERTRIEBS GmbH
TEL: 49-7452-2868
TLX: 765946 ENDRID
FAX: 49-7452-1470

MANHATTAN SKYLINE GmbH
TEL: 49-6128-23044
TLX: 4182704 MSKL D
FAX: 49-6128-21478

SCHUKAT ELECTRONIC
TEL: 49-2173-39660
TLX: 8515732 SELE D
FAX: 49-2173-396681

FINLAND
YLEISELEKTRONIIKKA OY
TEL: 358-0-452-1255
TLX: 123212 YLEOY SF
FAX: 358-0-428-932

IRELAND
NELTRONIC LTD.
TEL: 353-1-501845
TLX: 93556 NELT EI
FAX: 353-1-552789

ITALY
ESCO ITALIANA S.P.A.
TEL: 39-2-240-9241
TLX: 322383 ESCOM I
FAX: 39-2-240-9255

NETHERLANDS
ELINCOM ELEKTRONISCHE COMPONENTEN
TEL: 31-5990-14830
TLX: 53378 EUN NL
FAX: 31-5990-20360

PORTUGAL
NIPOSOM
TEL: 01-894637
FAX: 01-809617
TLX: 14028 NIP P

SPAIN
VENCO ELECTRONICA S.A.
TEL: 34-1-330-9751
TLX: 98266 VNCE E
FAX: 341-421-9377

SWITZERLAND
ICCM ELECTRONICS AG
TEL: 41-432-3434
TLX: 822101 ICM CH
FAX: 41-1-432-1070

SWEDEN
TOPCOMP ELECTRONICA
TEL: 46-8-757-4171
TLX: 812-5008 COMEKA S
FAX: 46-8-752-9265

UNITED KINGDOM
MANHATTAN SKYLINE LTD.
TEL: 44-628-75851
TLX: 847898 MANSKY
FAX: 44-628-782-812

METL
TEL:44-844-278781
FAX: 44-844-278746
TLX: 827150

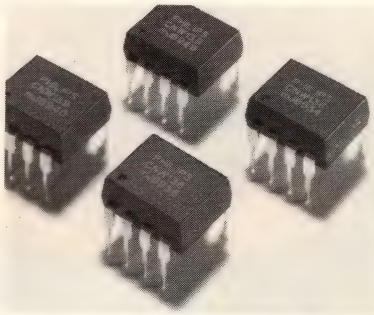
Components News

FROM YOUR STRATEGIC PARTNER

Philips Components, Marketing Communications Dept.
Building BA, Eindhoven, The Netherlands.
Telefax: +(31)40 72 28 61

DIP optocouplers provide 7 kV DC isolation and 11 MHz bandwith

Three new high-speed optocouplers from Philips Components withstand 7 kV DC (5 kV RMS) between the terminals of their wide-bodied DIL-8 package. The optocouplers have short propagation delay times of typically just 0.8 µs,



These TTL-compatible optocouplers are suited for demanding applications.

and a high 3 dB bandwidth of 11 MHz. Aimed at consumer and industrial applications, the CNW135, CNW136 and CNW4502 are ideal for application in high-reliability medical and professional equipment.

These TTL-compatible optocouplers have an infra-red emitting GaAlAs diode optically coupled to a silicon photodetector. The maximum DC output current is 10 mA, and the maximum collector-emitter voltage is 20 V. With an input current of 16 mA, a supply voltage of 4.5 V, and an output voltage of 0.4 V, the DC current transfer ratio is at least 0.19 (CNW136/4502). The saturation voltage is low, while the common-mode transient immunity is a high ±1.0 kV/µs. The CNW4502 has no base connection, thus providing increased ESD protection and high common-mode rejection.

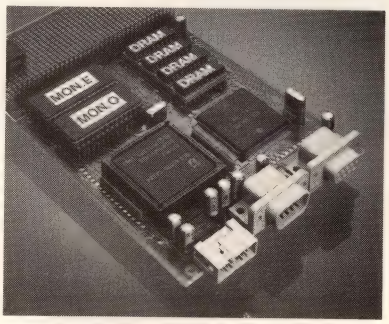
The optocouplers comply with VDE 0883, UL 1577 and IEC/BSI specifications. Samples are available now.

Circle 110

Video and system controller replaces up to 30 ICs in display systems

By integrating all of the glue logic needed for 68000-based systems, a new video and system controller circuit from Philips replaces around 30 ICs, allowing for the construction of colour display systems with a quarter of the number of components previously required. Featuring a resolution of 768 by 560 pixels, the SCC66470 is suitable for application in PCs, colour monitors, videotex terminals, industrial man-machine interfaces, and CARIN process control systems. The IC also works in CDI (interactive Compact Disc) systems.

The SC66470 is a colour display controller, system controller and image manipulator in one IC. It offers acceleration logic and fast image manipulation; an operation (including copy, swap, and patch) on a 16-bit word takes less than 500 ns. This is between three and



The high level of integration of the Philips SCC66470 video and system controller slashes system costs.

eight times faster than the 68000, and adding a co-processor for dedicated drawing or image manipulation can increase this speed advantage by a factor of three or five.

The IC offers acceleration logic and fast image manipulation; an operation (including copy, swap, and patch) on a 16-bit word takes less than 500 ns. This is between three and eight times faster than the 68000, and adding a co-processor for dedicated drawing or image manipulation can increase this speed advantage by a factor of three or five.

The chip connects directly to 68000-family ICs or, via extra glue logic, to other families such as the 8086 and 80186. It reads a bit-map into dynamic RAM, manipulates the image, serializes the pixels, and displays them on a screen at up to 15 MHz. The IC also incorporates system controller functions (such

PASSIVES ▫ LCDs ▫ SEMICONDUCTORS ▫ DISPLAY
Philips Components

as address decode, reset, and time-out signals) for 68000 systems.

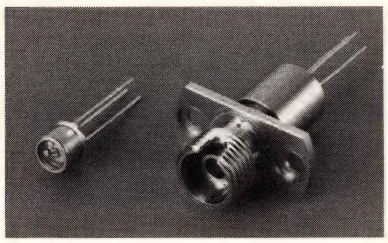
The circuit works with 50 or 60 Hz screens, as well as double frequency scan types. It comes in a 120-pin plastic quad flatpack. A 'microcore' board is available for system evaluation, development and prototyping.

Circle 111

Advanced planar technology produces InGaAs/InP PIN photodiodes

Philips Components has introduced a range of PIN photodiodes using the advanced 90 µm planar top-entry crystal structure, based on MOVPE technology. These InGaAs/InP diodes, for both 1.3 µm and 1.55 µm fibre-optic wavelengths, can receive at bit rates up to 2.4 Gbits/s.

The CPF30 is a large-area photodiode (350 x 300 µm) for use in short and medium distance links as well as in measurement equipment. The CPF31 features a smaller sensitive area (90 µm diameter)



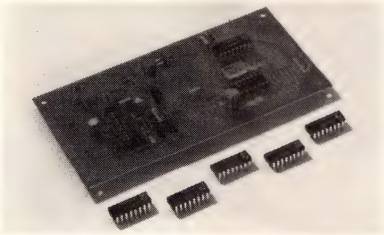
The CPF31/21 InGaAsP/InP photodiodes are also available in receptacles.

and is intended for use in medium and long distance fibre-optic links. Both types are packaged in a modified flat window low-profile TO-18 encapsulation. A receptacle-mounted version of the CPF31 (designated the CPF31/21) is also available. All types feature superior responsivity, extremely low dark current, high-stability and long lifetimes.

Circle 112

DTMF dialler with redial improves system cost effectiveness

Two CMOS DTMF diallers from Philips Components cost just



The PCD4420 and PCD4421 DTMF diallers incorporate functions for PABX.

US$1.00 each in quantities of 100000, and feature 23-digit redial. The PCD4420 and PCD4421 diallers meet CEPT distortion specifications without requiring external components, and offer special features for PABXs. Retaining the RAM contents right down to 1 V, they work from a supply voltage that can vary between 2.5 and 6 V, and have a mere 1.5 µA standby current.

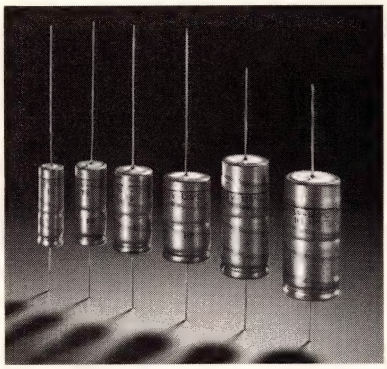
The dialler implements special PABX features such as flash, access pause, and disconnect. When dialling from a PABX to the public network, an access pause can be inserted after the first digit. The IC also works in sets which provide remote banking facilities, programmed alarm-calls, and so on.

The PCD4420 comes in a 16-lead DIL or SO package, the PCD4421 in an 18-lead DIL or 20-lead SO package. They draw a maximum of 150 µA during conversation mode, and 1 mA during dialling.

Circle 113

Non-solid aluminium electrolytics with CECC approval

Philips Components' 119 series non-solid aluminium electrolytic capacitors are now available with full CECC approval under detailed specification CECC 30 301-802. These compact electrolytics are high-reliability, long-life components intended for use in extreme ambient temperatures (such as in military, automotive and telecommunications applications). Specified from −55 to +125 °C, they're available in the E6-series capacitance values from 1 to 4700 µF, and with a rated voltage range (U_R) of 10 to 63 V. Under endurance test conditions at 125 °C and with maximum ripple current, the 119 series capacitors operate for 2000 hours.



These CECC-approved 119 series non-solid electrolytics can be used in extreme ambient temperature.

CECC inspections are carried out on large lots instead of small delivery lots. This means customers can confidently reduce incoming inspection to visual checks for transit damage. CECC approval can also be incorporated into ship-to-stock programmes.

Circle 114

COMPONENTS ▫ INTEGRATED CIRCUITS ▫ MATERIALS

PHILIPS

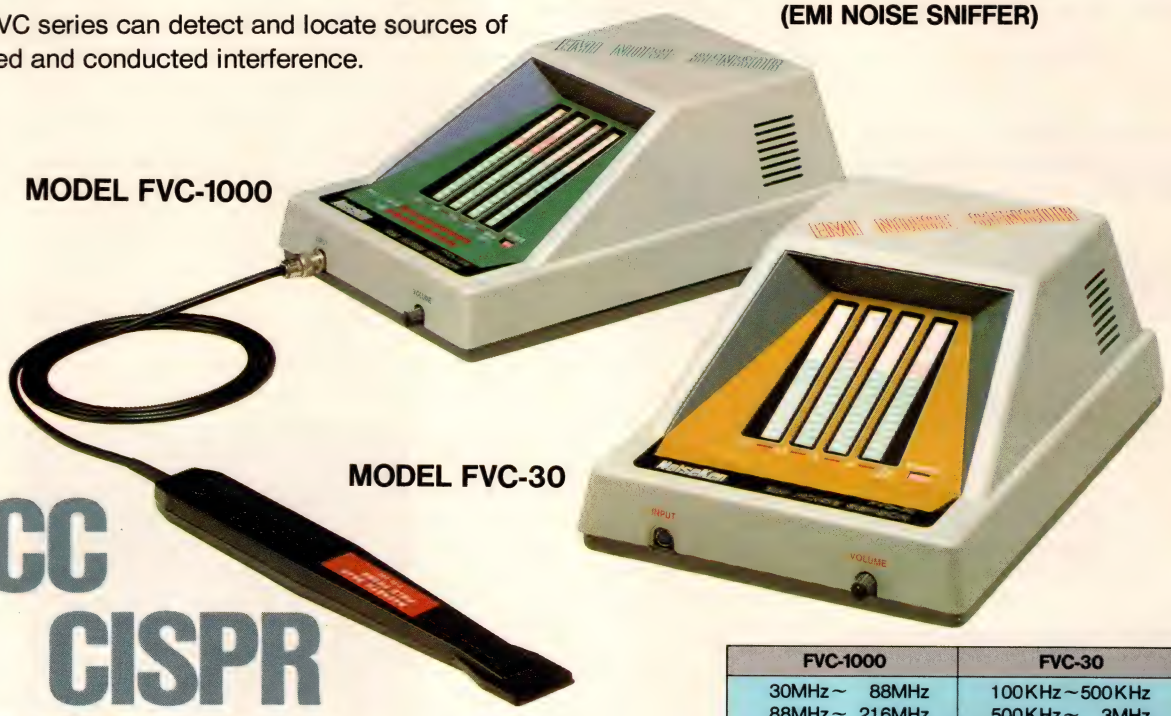
PHILIPS

NoiseKen

EMI Noise Sensor

(EMI NOISE SNIFFER)

The FVC series can detect and locate sources of radiated and conducted interference.



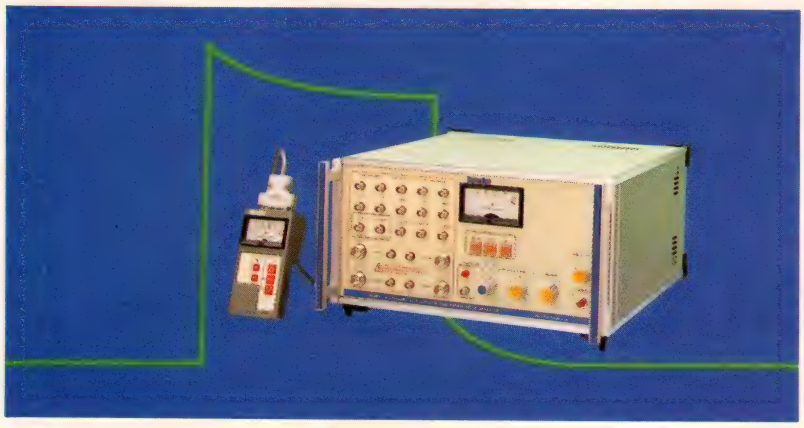
MODEL FVC-1000

MODEL FVC-30

FCC
CISPR
VDE

FVC-1000	FVC-30
30MHz～ 88MHz	100KHz～500KHz
88MHz～ 216MHz	500KHz～ 3MHz
216MHz～ 470MHz	3MHz～ 10MHz
470MHz～1000MHz	10MHz～ 30MHz
※Simultaneous 4 spectra measurement	※Simultaneous 4 spectra measurement

Noise simulators help find peril in power-line defects



Designers can use testers to build in safeguards against disturbances in power sources before sensitive equipment goes to customer

IMPULSE NOISE SIMULATOR
MODEL INS-410

VOLTAGE DIP SIMULATOR
MODEL VDS-210B

U.S.A. WATAHAN NOHARA INTERNATIONAL, INC. TEL (800) 366-3515

NOISE LABORATORY CO., LTD. 1-10-18, HIGASHIIKUTA TAMA-KU, KAWASAKI CITY, KANAGAWA PREF, 214 TEL(044)933-6411 FAX(044)932-4673
NOISE LABORATORY CO., LTD. TAIPEI LIAISON OFFICE 2FL., 129 TACHIH ST., TAIPEI TAIWAN R.O.C. TEL(02)506-0526～7 FAX(02)506-0848
DONGHAE COMPANY GA-326, JEONJA SANGGA 19-DONG, HANGANGRO 2GA, 15, YONGSAN-KU SEOUL, KOREA TEL(02)701-0756 FAX(02)701-0757

NOISE® NOISE LABORATORY CO., LTD.

Overvoltage protection for digital inputs, too

In Doug Conner's article on analog switches and multiplexers (EDN, March 15, 1990, pg 130), a great deal was mentioned about protecting CMOS switches from overvoltage damage. However, protecting only the analog inputs from overvoltage damage was explained, totally neglecting any input protection scheme for the digital inputs (for example, address-decoder inputs).

A problem area occurs when digital power-supply voltage (5V) may be available before analog power-supply voltage (12 or 15V), upon start-up or when a voltage is unintentionally disconnected from the system (See figure below). This condition makes the system susceptible to sneak-current paths (**a**) due to unintended current flow from the logic circuitry through the digital inputs of the analog multiplexer. These sneak currents could overstress or damage the multiplexer. This condition is further exasperated if the multiplexer and digital address source are remotely located—for example, on separate boards.

Two possible ways (**b**) to mitigate this problem area are as follows: By adding a Schottky diode—that is, a 1N5818 or an equivalent device with a Vf≤0.6V—between the digital power-supply line and the analog power-supply line; and by adding series resistors on the outputs of the digital address source device(s).

The following should also be noted: Some manufacturers (for example, Harris and Maxim) do provide input protection on their digital-address-decode lines; and you should avoid mixing devices that have input protection (analog or digital) with devices that don't have input protection in the same design.

David Weidlich
Senior Reliability Engineer
Product Assurance Laboratory
Raytheon Company Missile Systems Div
Tewksbury, MA

(Ed Note: You can use the methods shown in the box (EDN, March 15, 1990, pg 136) to protect the digital inputs as well as the analog inputs of analog switches and multiplexers. The added series resistance can slow the switching times slightly.

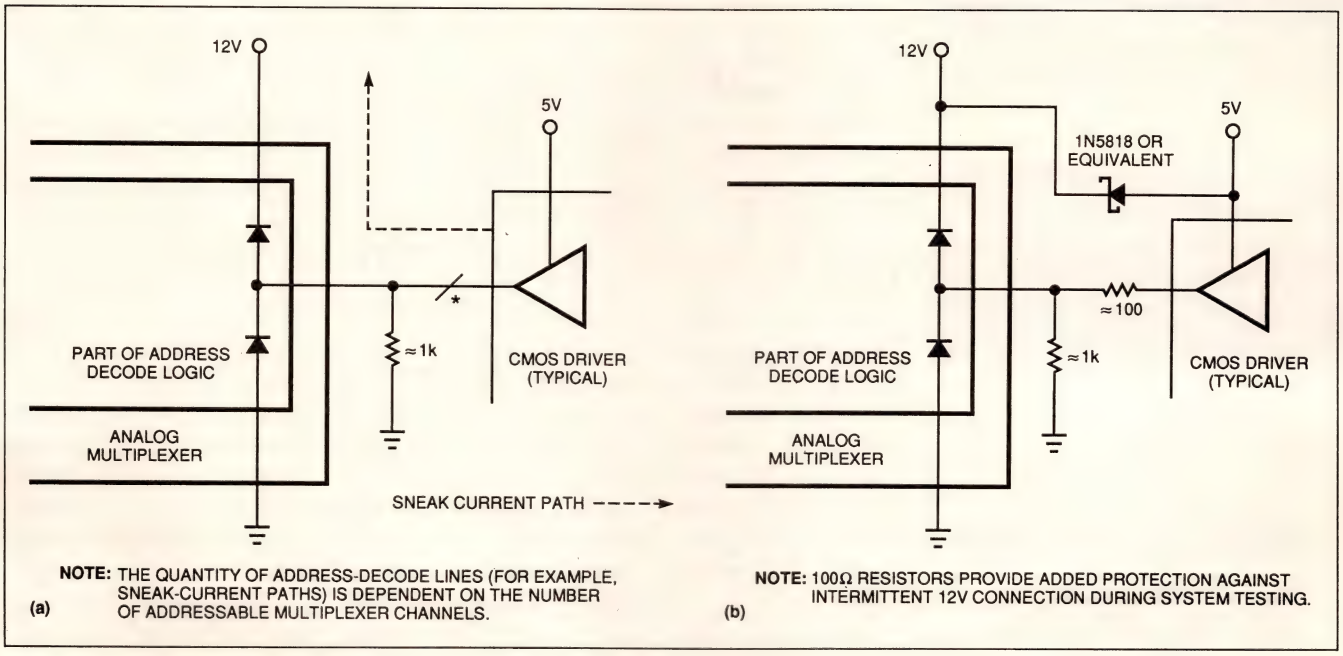
The method shown here in ***b****, using a Schottky diode between the 5 and 12V lines, will work if you don't have low impedance loads that will overload the Schottky diode. This method includes the unpowered 12V power supply on the 12V line.)*

A letter to CCEE readers

Irwin Feerst's efforts on behalf of EEs have long been the most important part of his life. He would never voluntarily give up his crusade. It is sadly evident, however, that he can no longer produce the CCEE (Committee of Concerned EEs) newsletter.

Irwin is very ill with motor neuron disease (ALS). He is an invalid confined to his home. It is necessary for me, his wife, to act for him in many capacities. This letter is something I am doing for him and for his supporters and readers. Irwin would never give up, but fate has taken the decision out of his hands.

Some CCEE members have expressed their concern about the future of CCEE. Some have indicated an interest in reaching out to others. There are just enough funds on hand to send out one more issue to all those on the mailing list. If you wish to solicit the support of, or to contact other interested parties, your message and your ad-



NOTE: THE QUANTITY OF ADDRESS-DECODE LINES (FOR EXAMPLE, SNEAK-CURRENT PATHS) IS DEPENDENT ON THE NUMBER OF ADDRESSABLE MULTIPLEXER CHANNELS.
(a)

NOTE: 100Ω RESISTORS PROVIDE ADDED PROTECTION AGAINST INTERMITTENT 12V CONNECTION DURING SYSTEM TESTING.
(b)

Analyzer488
Benchtop or
PC operation.



Use the compact Analyzer488 to develop, debug, and optimize your IEEE systems from the benchtop. Or connect it to your PC or PS/2 and use the powerful analysis software included with the unit.

Only the Analyzer488 lets you do both.

The built-in 32 Kbyte memory and comprehensive triggering let you capture bus transactions at a full 1 Mbyte/sec. And because the memory is non-volatile you can transport the Analyzer488 to your PC for further analysis and save the data to disk.

All for a surprisingly low $1,495.

Call today for your free Technical Guide to the Analyzer488 and other IEEE 488 products from IOtech: 216-439-4091.

IBM PC, AT, 386, and PS/2 IEEE Products
Macintosh IEEE Products
Sun and DEC Workstation IEEE Products
Serial/IEEE Converters and Controllers
Analog and Digital I/O Converters to IEEE
IEEE Analyzers, Converters, and Extenders

IOtech

IOtech, Inc. • 25971 Cannon Road
Cleveland, Ohio 44146
PHONE 216-439-4091 • FAX 216-439-4093
CIRCLE NO. 20

dress can be published, at no cost to you.

The mailing list and record of supporters cannot be handed over to anyone, as some people have requested privacy. Also, it is neither appropriate nor feasible to continue my involvement.

Please do not send money. There is just the right amount left to send out the next issue so that those of you who wish to carry on can find each other. To have money left over would be an extra burden for me.

Many CCEE readers are also friends. Let me tell you some of Irwin's limitations should you wish to reach him. It is difficult for him to speak, and he no longer uses the telephone. He tires quickly and is only able to enjoy brief visits from people he knows well. Although he can do very little, he is, at the time of this writing, not uncomfortable. If you write, brevity and simplicity would be best.

I expect to send out the next (final) mailing around July 1, 1990. Any CCEE subscriber who wishes to communicate with other CCEE readers will have time to send messages to be published.

Frances Feerst
Committee of Concerned EEs
Massapequa Park, NY

Questions and answers about op-amp macromodels

I read Mark Alexander's and Derek Bowers's article on Spice-compatible op-amp macromodels (EDN, February 15, 1990, pg 143) with great interest, and I'd like to add some comments. Mark and Derek state that a serious disadvantage of the Boyle macromodel (Fig 1) arises from the fact that a number of current sources are related to "ground,"—that is, to a point that does not physically exist in most operational amplifiers. When modeling the output current of the op amp, it is of minor importance in my opinion, whether current sources are related to "ground" or to the supply rails. But I agree that the new model in Fig 3 is closer to reality because the output current is either drawn from the positive supply or flows into the negative supply. Hence, the new macromodel enables the user to get the correct supply currents too.

I found a minor flaw in Fig 3. It contains a formula for the input offset voltage of the op amp:

$$E_{OS} = V_{OS} + (V_E - V_H).$$

This formula should read:

$$E_{OS} = V_{OS} + (V_E - V_H)/CMR,$$

where CMR is the common-mode-rejection factor of the op amp. Without this factor, E_{OS} would become unreasonably large; that is, it could be almost as high as the supply voltage, V_{CC}. The voltage V_E is probably the emitter potential of the differential pair at the input stage; it has been forgotten in the figure.

Roland E Best
Asst Vice President, Engineering
Sandoz Pharmaceuticals Ltd
4002 Basel, Switzerland

(The Authors' Reply: We thank Roland Best for his interest in the op-amp modeling article. In our opinion, the lack of correct output current modeling in the Boyle macromodel is a disadvantage and is one that completely precludes its use in certain areas. Because the output current in the Boyle model flows from a grounded source, the user is prevented from obtaining an accurate estimate of total supply current when the op amp(s) in a simulated circuit are driving any kind of load. Therefore, power-supply budgeting will be rather difficult to do, especially in a system that utilizes numerous amplifiers. Additionally, a class of op-amp circuits makes use of supply-rail current sensing in the process of generating an output signal, and these circuits cannot be simulated using the Boyle model. The following references provide more information on this

Z I L O G

Z8 CCP™

The 8-bit CMOS Consumer/Control Processor with the most exciting feature set you've ever seen.

The low-cost Z8 CCP family of microcontrollers takes full advantage of Zilog's new Superintegration™ Z8® core. The result is unprecedented functionality at a price that makes sense for high volume consumer and automotive products as well as intelligent embedded peripherals.

Features . . .

For starters, there's a voltage detection circuit that automatically triggers an on-board power-on reset timer for no-fuss power up. And it continues to provide brown-out protection . . . in case Vcc falls below the 2.5-5.5 volt operating range. Not only that, there's an on-board watchdog timer that secures your application even further.

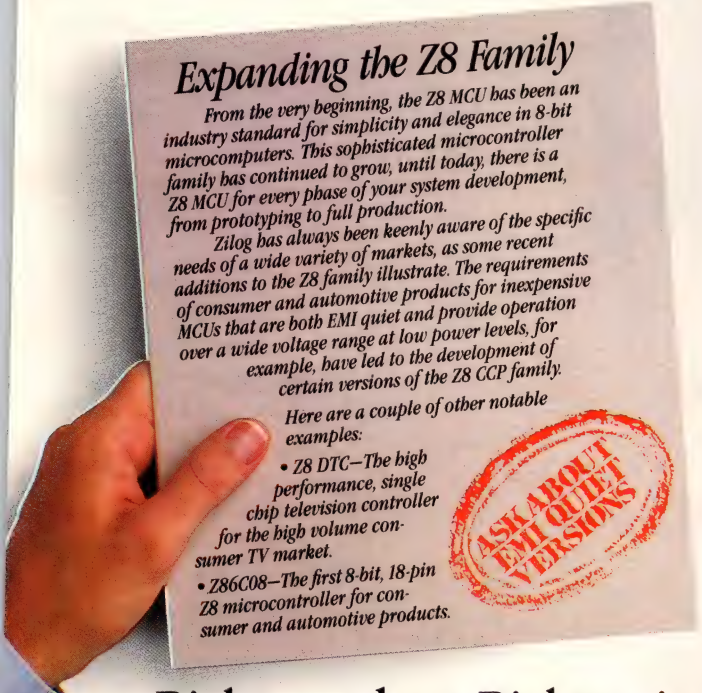
. . . and more features.

You also get a stop mode that typically consumes less than 2 microamps. What's more, stop-mode wake-up and interrupts can be triggered from multi-input port transitions, making the Z8 CCP MCU ideal for key-pad applications. And that's not all. The Z8 CCP series gives you on-board analog comparators, two 8-bit counter/timers, with 6-bit pre-scaler, and the right amount of I/O. And you know you're going to get very fast code development, because you've got full compatibility with the widely used 8-bit Z8 instruction set.

And plenty of important choices.

Choose between low EMI wide voltage range or high-speed control devices. The Z8 CCP microcontroller is also available in your choice of RC, ceramic or crystal oscillator circuits. And in 18-, 28-- and 40/44-pin versions, in a variety of packages, with 2K or 4K ROM Code sizes. All off the shelf and backed by Zilog's proven quality and reliability.

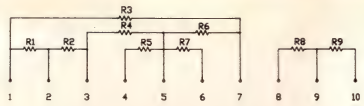
To find out more about the Z8 CCP MCU or any of Zilog's rapidly growing family of Superintegration products, contact your local Zilog sales office or your authorized distributor today. Zilog, Inc., 210 Hacienda Ave., Campbell, CA 95008, (408) 370-8000.



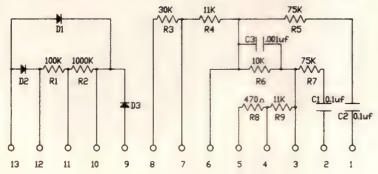
Right product. Right price. Right away.

ZiLOG

ZILOG SALES OFFICES: CA (408) 370-8120, (714) 838-7800, (818) 707-2160, **CO** (303) 494-2905, **FL** (813) 585-2533, **GA** (404) 923-8500, **IL** (312) 517-8080, **NH** (603) 888-8590, **MN** (612) 831-7611, **NJ** (201) 382-5700, **OH** (216) 447-1480, **PA** (215) 653-0230, **TX** (214) 987-9987, **CANADA** Toronto (416) 673-0634, **ENGLAND** Maidenhead (44) (628) 39200, **W. GERMANY** Munich (49) (89) 672045, **JAPAN** Tokyo (81) (3) 587-0528, **HONG KONG** Kowloon (852) (3) 723-8979, **KOREA** (82) (2) 552-5401, **TAIWAN** (886) (2) 741-3125, **SINGAPORE** 65-235 7155, **DISTRIBUTORS: U.S.** Anthem Electronics, Hall-Mark Electronics, JAN Devices, Inc., Schweber Electronics, Vargas Electronics, Western Microtechnology, **CANADA** Future Electronics, SEMAD, **LATIN AMERICA** Argentina—Vel.-(1) 46-2211, Brazil—Digibyte (011) 581-1945.



CUSTOM THICK FILM NETWORKS



Fast turnaround on U.S. made DIPs and coated/molded SIPs. • Unlimited schematics combining resistors, inductors, capacitors and diodes. • Complete capabilities from design through production. • Lead lengths up to 0.290". • Special performance ranges, plus production and testing to M83401 levels.

Call or Fax your requirements to:

TECHNO DIVISION
DALE ELECTRONICS, INC.
• • • a VISHAY Company
7803 Lemona Ave. • Van Nuys, CA 91405-1139

Phone (818) 781-1642 • FAX (818) 781-8647

CIRCLE NO. 22

AUDIO PRO



Introducing...CD quality, stereo high fidelity, digital audio you record and playback on your PC-AT/286/386/Model 30 or compatible.

Featuring...real time direct to disk data transfer... 16-bit resolution...20Hz to 20kHz audio response... 0.005% THD...6.25 to 50kHz programmable sample rate...92dB dynamic range...90db s/n...digital input ...4 to 1 ADPCM compression.

Use for digital audio recording, editing, mastering and transmission in broadcasting, entertainment systems, film production, audio/visual presentations and interactive CDI/DVI systems.

If you're an audiophile with microcomputer resources call 1-800-338-4231 (ex. CA.) for details on our Audio Pro...the Series 2/Model SX-10.

ANTEX ELECTRONICS
16100 S. Figueroa St. • Gardena, CA 90248 • Tel (213) 532-3092 • FAX (213) 532-8509

CIRCLE NO. 23

class of circuits:

1. Alexander, Mark, "A Current-Feedback Audio Power Amplifier," 88th Convention of the Audio Eng Soc, preprint #2902, March 1990.

2. Tomazou, C, F J Lidgey, and A Makris, "Extending voltage-mode op amps to current-mode performance," IEE proceedings, Vol 173, Pt G, No. 2, April 1990, pg 116.

3. Tomazou, Chris and John Lidgey, "Fast current-mode precision rectifiers," Electronics & Wireless World, Vol 93, No. 1621, November 1987, pg 1115.

The original impetus behind creating a new macromodel that correctly splits the output current between the power-supply rails was a desire to mimic the behavior of a real op amp more closely, thus allowing simulation of a wider range of circuits.

Regarding the formula for the input offset voltage in Fig 3, the text states that voltage generated by the common-mode processing stage (Fig 4) is added back to the input offset source. This voltage (V_E in Fig 4) has already received the necessary scaling because the voltage-controlled current sources in the common-mode stage have a g_m that's scaled by a factor of 1/CMRR. Thus V_E is not the voltage at the emitters of the differential input pair, but is rather a scaled and frequency-shaped version of V_{CM}. We apologize for any confusion that may have arisen out of the labeling process, and that resulted in the processed common-mode voltage being referred to as V_E and not something else.)

EDN

WRITE IN

Send your letters to the Signals and Noise Editor, 275 Washington St, Newton, MA 02158. We welcome all comments, pro or con. All letters must be signed, but we will withhold your name upon request. We reserve the right to edit letters for space and clarity.

Introducing the world's first data acquisition software machine.



New DT2831 family of PC/AT boards eliminates manual adjustments.

Once you've plugged a DT2831 Series board into your PC/AT, you can forget it. Our unique "Hands-Off" hardware design takes the hassle out of data acquisition, by eliminating all manual adjustments. *Good-bye, jumpers! Good-bye, pots!*

Now, for the first time, data acquisition set up and calibration can be handled instantly and automatically, via software control. Critical, software-controlled functions include:

- Single-ended or differential input selection.
- Input gain selection.
- Input and output coding range selection.
- Selection of DMA channels.
- Selection of interrupt levels.

Even the onboard A/D converter, at power up, self-calibrates! What's more, analog input circuitry and D/A calibration can be controlled from the keyboard via software.



–Fred Molinari, President

Good-bye, screwdriver!

And we provide the software—FREE! Each DT2831 Series board ships with a device driver, that self-installs upon power up, and a ToolKit that is language and device independent, so one program runs any DT2831 Series board, without modification.

For application software, ask us about GLOBAL LAB ($995) or other industry-standard packages.

Call (508) 481-3700

In Canada, (800) 268-0427



FREE 1990 Data Acquisition Handbook

OVER DELIVERY NIGHT

	DT2831	DT2835	DT2831-G
Fully Software Configurable/Calibratable	✓	✓	✓
Analog Inputs	16SE/8DI; 50kHz 12-bit, high level	16SE/8DI; 50kHz 12-bit, low level	16SE/8DI; 250kHz 12-bit
Analog Outputs	2 Channels: 130kHz, 12-bit		
Counter/Timers	2 (Am9513A)		
Digital I/O	8 lines		
Channel Expansion	up to 256	up to 256	–

DATA TRANSLATION®

World Headquarters: Data Translation, Inc., 100 Locke Drive, Marlboro, MA 01752-1192 USA, (508) 481-3700, Fax (508) 481-8620, Tlx 951646
United Kingdom Headquarters: Data Translation Ltd., The Mulberry Business Park, Wokingham, Berkshire RG11 2QJ, U.K., (734) 793838, Fax (734) 776670, Tlx 94011914
West Germany Headquarters: Data Translation GmbH, Stuttgarter Strasse 66, 7120 Bietigheim-Bissengen, West Germany 7142-54025, Fax 7142-64042
International Sales Offices: Australia (2) 662-4255; Belgium (2) 466-8199; Brazil 11 240-0598; Canada (416) 625-1907; China (1) 868-721 x4017; Denmark 2 274511; Finland (0) 3511800; France (1) 69077802; Greece (1) 361-4300; Hong Kong (5) 448963; India (22) 23-1040; Israel 52-545685; Italy (2) 82470.1; Japan (3) 502-5550, (3) 5379-1971, (3) 355-1111; Korea (2) 718-9521; Netherlands (70) 399-6360; Norway (2) 53 12 50; Poland (22) 580701; Portugal (1) 545313; South Africa (12) 803-7680; Spain (1) 555-8112; Sweden (8) 761 78 20; Switzerland (1) 723-1410; Taiwan (2) 3039836

Data Translation is a registered trademark of Data Translation, Inc. Other brands and products are trademarks of their respective holders.

Mixed-signal ASICs

NCR

A lot of designers have mixed feelings about mixed-signal ASICs.

They know they need a higher level of integration on their silicon. But they also know that mixed-signal ASICs can be a challenge. A big one.

For these designers, NCR meets the challenge.

NCR has digital and analog libraries – characterized over all temperatures with functions ranging to 12-bit A/Ds and CMOS processes from 1.5 to sub-micron. With user friendly software tools to put them together.

And, with NCR DesignSim A & D – a comprehensive Analog/Digital System Simulation Package, you may simulate the individual ASIC or the entire system!

NCR also provides off-the-shelf kit parts for in-depth system evaluation, and custom designed cells for special requirements.

NCR can deliver a few prototypes or a few hundred thousand parts all manufactured on the same production line. Assuring continuity in process and quality.

Finally NCR has a mixed-signal test environment created specifically to test Analog/Digital ASICs without compromising either domain.

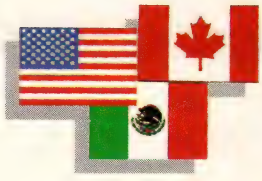
All this has resulted in NCR being ranked #1 in worldwide cell-based mixed-signal ASIC suppliers*.

And that's why designers who know NCR, don't have mixed feelings about mixed-signal ASICs.

Call 1-800-334-5454 for complete information.

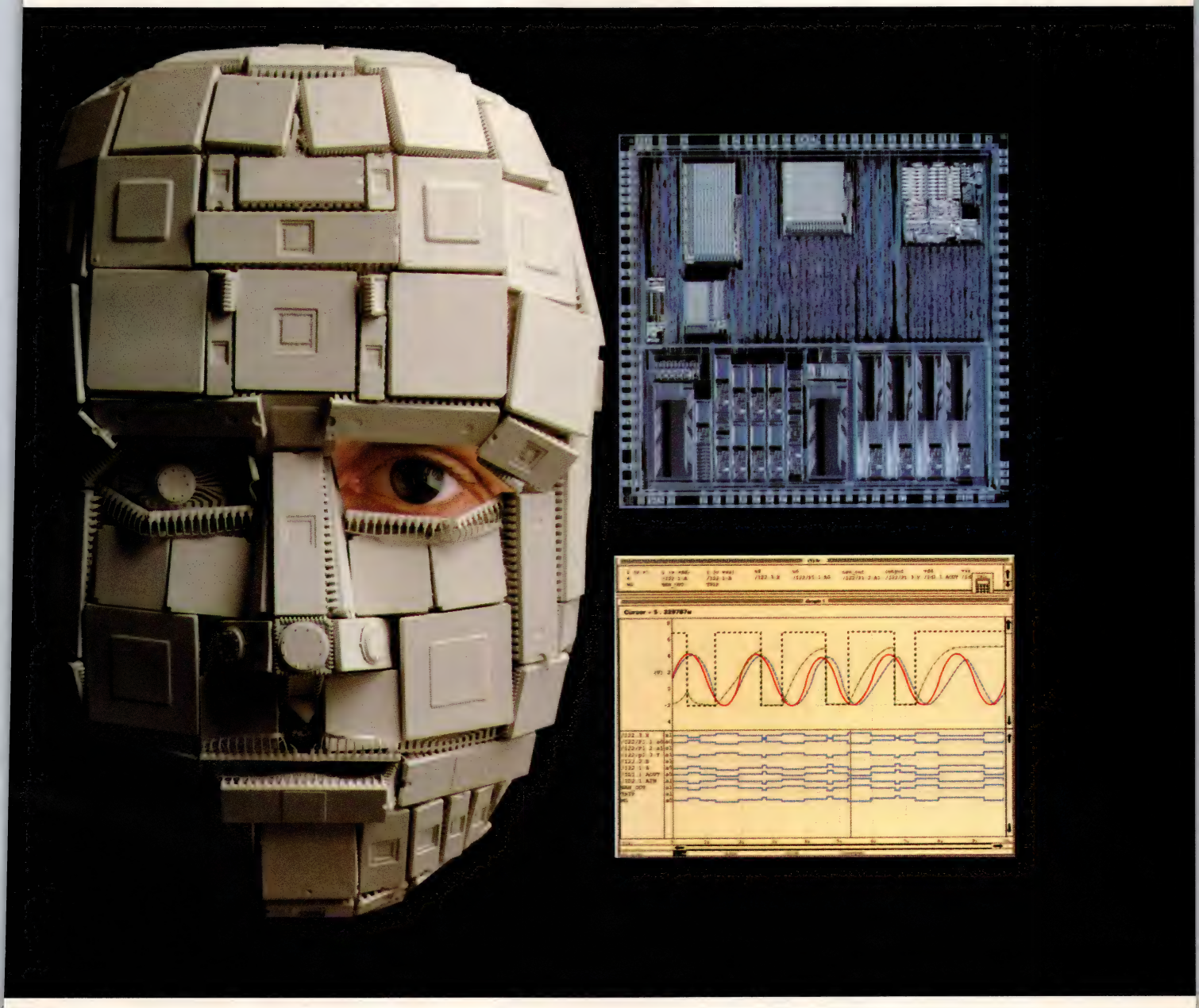
**Integrated Circuit Engineering, 1988/1989*

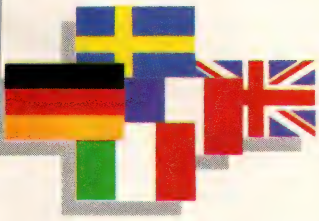
Creating value



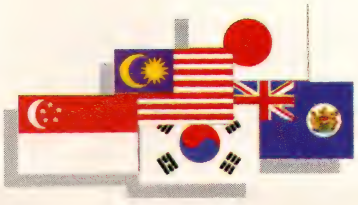
Worldwide Sales Headquarters
3130 De La Cruz Boulevard, Suite 209
Santa Clara, California 95054
1-800-334-5454

without mixed feelings





European Sales Headquarters
Gustav-Heinemann-Ring 133
8000 Munchen 83
West Germany
49 89 632202



Asia/Pacific Sales Headquarters
2501 Vicwood Plaza
199 Des Voeux Road
Central Hong Kong
852 859 6044

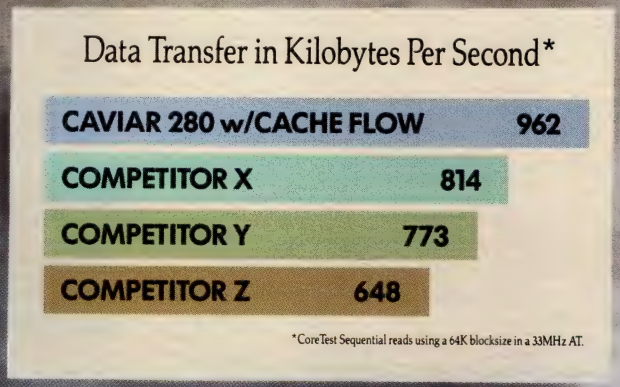
CIRCLE NO. 25

Why do you think they come with racing stripes?

Ladies and gentlemen, start your engines.

Because our new 80 and 40 Mb Caviar™ family of intelligent drives is going to give you the kind of system speed you've always wanted.

As you can see on the chart, no one can match our data throughput.



What's more, according to our incredibly conservative attorneys' interpretation of the benchmark data, the 80 Mb drive benchmarked an average access time of less than 18 milliseconds. And according to our engineers' interpretation, our attorneys are, indeed, incredibly conservative.

So what's the secret behind these high-performance, low-profile, 1-inch, 80 and 40 Megabyte AT compatible intelligent drives?

Some say it's our unique CacheFlow™ caching feature. A new generation design which constantly evaluates the way data is being retrieved from the drive and adapts to the optimum caching method. So disk seeking operations and latency delays are minimized. And throughput is increased.

Others say it's our unique InterArchitecture—the way we design and manufacture all our own chips, boards and drives to work together—that accounts for the speed.

Whatever the reason, the result is dramatically enhanced system performance.

So what are you waiting for?

For more information, call us at 1-800-4 INFO WD.

If it were easy, anyone could do it.

WESTERN DIGITAL

SEMICONDUCTORS • STORAGE • IMAGING • COMMUNICATIONS

Western Digital, Caviar™ and CacheFlow™ are trademarks of Western Digital Corporation. All other marks herein belong to other companies.


WARRANTY
VOID
IF REMOVED
WESTERN DIGITAL
WESTERN DIGITAL
WESTERN DIGITAL
WESTERN DIGITAL
WESTERN DIGITAL
WESTERN DIGITAL

CIRCLE NO. 26

AT YOUR COMMAND.



Data Acquisition and Instrument Control at Your Fingertips

With the CEC genie your wishes come true. You can control any IEEE-488 (HP-IB, GP-IB) instrument, printer, or plotter from your PC. CEC's plug-in cards come with a software library of example programs and utilities that let you spend more time solving problems than programming. CEC provides software support for BASIC, Pascal, C, and FORTRAN.

If your wish is for a custom program, CEC also offers software that writes '488 programs.



Simply pop up our software over your program editor and choose a control function or library for your instrument. Code is automatically generated from your choices. Press a key and the magic begins. The code appears where you want it in your program.

Now, make your wishes come true by calling 800-234-4232 for your FREE demo disk.

cec

Capital Equipment Corp.

99 South Bedford Street
Burlington, MA 01803
Tel: 617-273-1818 Fax: 617-273-9057

CIRCLE NO. 27

DID YOU KNOW?

Half of all EDN's articles are staff-written.

EDN

CALENDAR

DEXPO East 90, Boston, MA. Expoconsul International Inc, 3 Independence Way, Princeton, NJ 08540. (800) 873-3976; in NJ, (609) 987-9400. June 26 to 28.

TOOLS '90—Technology of Object-Oriented Languages and Systems, Paris, France. TOOLS '90, 14 rue Jean Rey, 75015 Paris, France. 40 56 03 58. FAX 40 56 05 81. June 26 to 29.

2nd International Symposium on Databases in Parallel and Distributed Systems, Dublin, Ireland. Sushil Jajodia, Association for Computing Machinery, George Mason University, Information Systems and Systems Engineering, Fairfax, VA 22030. (703) 764-6192. July 2 to 4.

2nd Annual Symposium on Parallel Algorithms and Architectures, Crete, Greece. Tom Leighton, Association for Computing Machinery, Math Dept and Lab for Computer Science, Massachusetts Institute of Technology, Cambridge, MA 02139. (617) 253-3662. July 2 to 6.

Problem Solving with PowerScopes (short course), Foster City, CA. Fred Tolliver, Basic Measuring Instruments, 335 Lakeside Dr, Foster City, CA 94404. (800) 876-5355. FAX (415) 574-2176. July 9 to 10.

Surface Mount and T/H Hand Soldering, Bethlehem, PA. National Training Center for Microelectronics, Northampton Community College, 3835 Green Pond Rd, Bethlehem, PA 18015. (215) 861-5450. FAX (215) 861-5060. July 9 to 11.

Hands-On Datacomm Troubleshooting (short course), San Diego, CA. Learning Tree International, 6053 W Century Blvd, Los Angeles, CA 90045. (800) 421-8166; in CA, (213) 417-8888. FAX (213) 410-2952. July 10 to 13.

Seagate's Technology

THE FINE ART OF DISC DRIVES



Neon Sculpture by
Lili Lakich
Los Angeles, California

To the naked eye, disc drives haven't changed much in the past few years. While the visible aspects have remained the same, the parts you can't see have improved dramatically. What used to be megabytes are now gigabytes. And Seagate is at the forefront of this technological revolution.

We've not only increased capacities, but we've found ways to make drives faster and more reliable. For example, Zone Bit Recording™ is a recording technique that permits higher capacity and faster average data transfer rates than conventional recording methods. Our straight-arm actuator has 60% less mass than most other designs, giving our Wren™ and Sabre™ families lightning-quick access performance. And by increasing spindle rotation 50% to 5400 RPM, we've significantly increased the transfer rate and reduced the latency in our 1.5 GB Elite™ drive.

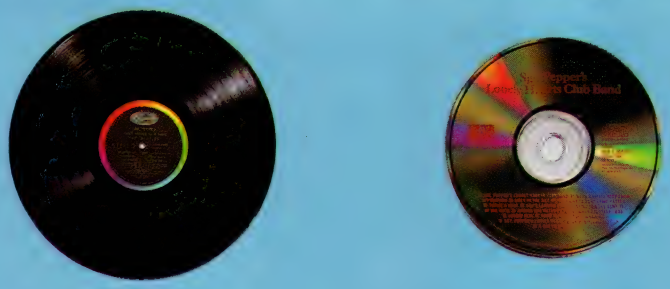
As a result of these and other technological improvements, Seagate now offers drives from 20 MB to 2.5 GB in the widest range of form factors and interfaces imaginable, for almost every conceivable application. And we're not through yet.

Like the artist who spends years perfecting his craft, Seagate has spent the past decade mastering the fine art of disc drives. To get a first-hand look at the state-of-the-art, contact your authorized Seagate distributor, or call Seagate directly: 800-468-DISC, or 408-438-6550.

Seagate

Zone Bit Recording, Wren, Sabre and Elite are trademarks of a wholly-owned subsidiary of Seagate Technology, Inc.;
Seagate and the Seagate logo are registered trademarks of Seagate Technology, Inc.
©1990 Seagate Technology, Inc.

Analog Design **Digital Design**



EE Designer III™

offers superb design and simulation capabilities for both.

Total Integration assures smooth, error-free data transfer throughout the system with functionally organized menus to speed you through your design jobs.

No Limitation means that EE Designer can handle SMT, ground planes with heat-relief pads, thermal analysis, hybrid designs and more.

After 6 years of development and continued refinement, EE Designer has proven to over 14,000 users world-wide to be the one system that gets the job done.

Find out more about EE Designer, the choice of serious PCB design professionals by calling Visionics/Betronex or your local EE Designer Value Added Reseller.

In North America
Visionics Corporation
3032 Bunker Hill Lane
Suite 201
Santa Clara, CA 95054
Tel: 1-800-553-1177
Fax: (408) 492-1380

International
Betronex International
Enhagsslingan 19
Box 314
183 24 Taby, Sweden
Tel: (46) 8 792-2630
Fax: (46) 8 768-8794

CIRCLE NO. 28

DID YOU KNOW?

EDN is distributed at every major electronics/computer show in the U.S., France, and Germany.

EDN

CALENDAR

Dynamic 3-D Computer Graphic Systems for Industrial Design, Monterey, CA. BIS CAP International, Research Publications and Conferences Div, Box 68, Newtonville, MA 02160. (617) 893-9130. FAX (617) 894-5093. July 11 to 13.

Modern Power Conversion Design Techniques, Chicago, IL. Joy Bloom, Bloom Associates Inc, Educational Div, 115 Duran Dr, San Rafael, CA 94903. (415) 492-8443. FAX (415) 492-1239. July 16 to 20.

Modern Coating Systems: Status and Directions, Boston, MA. BIS CAP International, Research Publications and Conferences Div, Box 68, Newtonville, MA 02160. (617) 893-9130. FAX (617) 894-5093. July 18 to 20.

End-Use Power Line Harmonics (short course), Chicago, IL. Fred Tolliver, Basic Measuring Instruments, 335 Lakeside Dr, Foster City, CA 94404. (800) 876-5355. FAX (415) 574-2176. July 19.

Microprocessor Troubleshooting: Hands-On Tools and Techniques (short course), San Diego, CA. Learning Tree International, 6053 W Century Blvd, Los Angeles, CA 90045. (800) 421-8166; in CA, (213) 417-8888. FAX (213) 410-2952. July 24 to 27.

Real-Time Programming: A Hands-On C Workshop (short course), Washington, DC. Learning Tree International, 6053 W Century Blvd, Los Angeles, CA 90045. (800) 421-8166; in CA, (213) 417-8888. FAX (213) 410-2952. July 24 to 27.

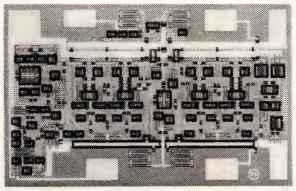
The PowerProfiler: Use and Application (short course), Foster City, CA. Fred Tolliver, Basic Measuring Instruments, 335 Lakeside Dr, Foster City, CA 94404. (800) 876-5355. FAX (415) 574-2176. July 26 to 27.

NOW PUT A LITTLE AVANTEK MAGIC IN YOUR SYSTEM

Avantek MagIC™ High Speed ICs Enable Superior System Designs

magIC™

The new MagIC™ series of silicon bipolar MSI integrated circuits offer the best performance available from silicon ICs yet. The broadband, high frequency performance of these high-speed silicon ICs make them cost-effective alternatives to more expensive GaAs ICs. Avantek MagIC silicon ICs are manufactured with Avantek's proprietary 10-15 GHz F_t, 25 GHz F_{max} Isosat™ process for unsurpassed integration and performance at microwave frequencies. Avantek's MagIC series ICs presently consists of four product families: low noise amplifiers, active mixers, variable gain control amplifiers, and prescalers. These low-cost, high-speed silicon ICs are Avantek's magic solutions to your RF, microwave and lightwave system performance and cost problems.



High Performance, High Speed, Low Cost...

The INA-series of two-stage low-noise amplifiers presently consists of three models, offering:

- 3 dB bandwidths to 2.8 GHz
- Gains as high as 32 dB
- Noise figures as low as 1.7 dB
- Prices as low as $22.00 each* in hermetic 70 mil surface mount package



The IAM-series of active mixer/amplifiers presently consists of two models, offering:

- RF and LO frequency range of .05 to 5.0 GHz
- Conversion gain as high as 15 dB
- LO power as low as −10 dBm
- Prices as low as $16.00 each* in hermetic 180 mil surface mount package

The IVA-series of variable gain control amplifiers presently consists of two models, offering:

- 3 dB bandwidths to 3.0 GHz
- 30 dB gain control range
- Gains as high as 26 dB
- Prices as low as $28.50 each* in hermetic 180 mil surface mount package

The IFD-series low phase noise static prescalers offer:

- Divide-by-4 to 5 GHz
- Low 125 mW Power Consumption
- Prices as low as $18.50 each* in hermetic 100 mil surface mount package

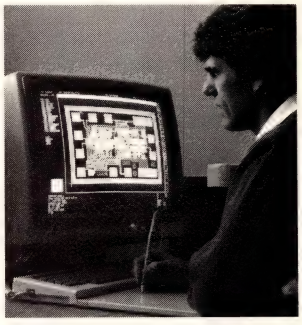
*Price for 1000 piece quantities

MagIC™ ICs Are Available in Quantity for Volume Applications

Avantek presently produces more than 1,000,000 MMICs per month. So you can be assured the MagIC high speed ICs you need will be available to support your volume production programs. And, all MagIC silicon ICs are in stock at your local Avantek distributor.

For additional information, or the name and address of your local distributor, contact the regional sales office nearest you.

Regional Sales Offices
North America
Eastern: (301) 381-2600
Central: (312) 358-8963
Western: (805) 373-3870
European: (44) 276-685753





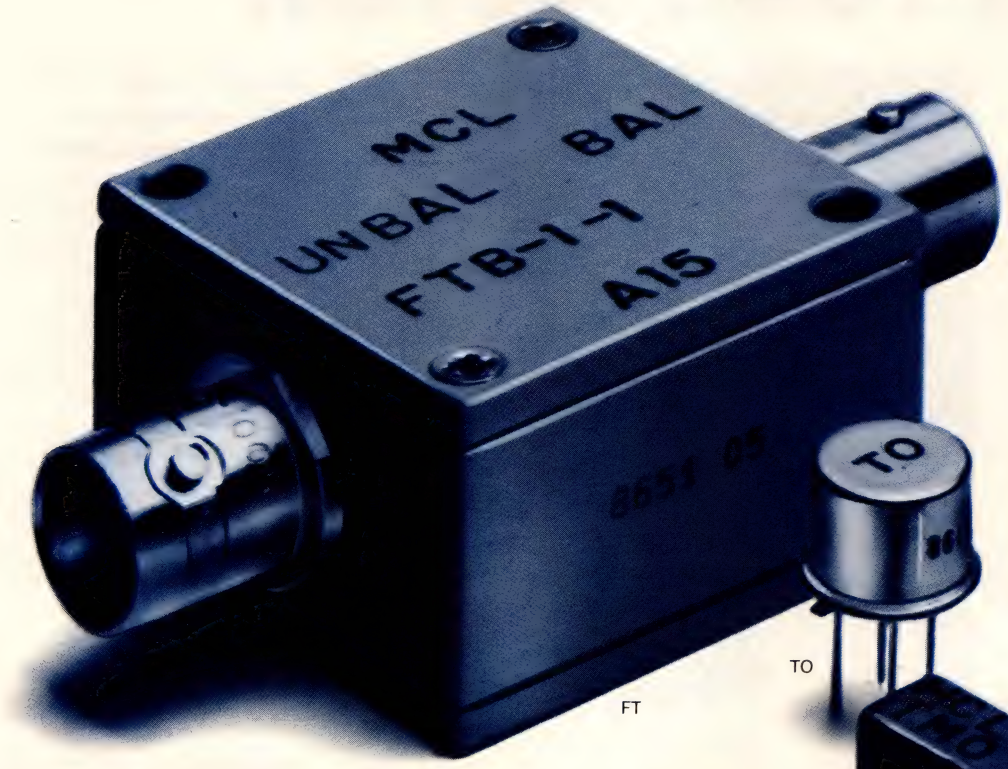
Magic Solutions in Silicon

AVANTEK

CIRCLE NO. 186

RF TRANS

Over 50 off-the-shelf models...



FT

TO

TMO

T, TH, TT

T, TH, TT
bent lead version
style X 65

T, TH, TT
bent lead version
style KK81

Having difficulty locating RF or pulse transformers with low droop, fast risetime or a particular impedance ratio over a specific frequency range?...Mini-Circuits offers a solution.

Choose impedance ratios from 1:1 to 36:1, connector or pin versions (plastic or metal case built to meet MIL-T-21038 and MIL-T-55831 requirements*). Ultra-wideband response achieves low droop and fast risetime for pulse applications. Ratings up to 1000M ohms insulation resistance and up to 1000V dielectric voltage. For wide dynamic range applications involving up to 100 mA DC primary current, use the T-H series. Coaxial connector models are offered with 50 and 75 ohm impedance; BNC standard; request other types. Available for immediate delivery with one-year guarantee.

Call or write for 68-page catalog or see our catalog in EEM, or Microwaves Product Data Directory.

*units are not QPL listed

case styles
T, TH, case W 38, X 65 bent lead version, KK81 bent lead version
TMO, case A 11, † case B 13 FT, FTB, case H 16
NEW TC SURFACE MOUNT MODELS from 1MHz to 1500 MHz

NSN GUIDE

MCL NO.	NSN	MCL NO.	NSN
FTB1-1-75	5950-01-132-8034	TMO2-1	5950-01-183-6414
FTB1-6	5950-01-225-8773	TMO2.5-6	5950-01-215-4038
T1-1	5950-10-128-3745	TMO2.5-6T	5950-01-215-8697
T1-1T	5950-01-153-0668	TMO3-1T	5950-01-168-7512
T2-1	5950-01-106-1218	TMO4-1	5950-01-067-1012
T3-1T	5950-01-153-0298	TMO4-2	5950-01-091-3553
T4-1	5950-01-024-7626	TMO4-6	5950-01-132-8102
T9-1	5950-01-105-8153	TMO5-1T	5950-01-183-0779
T16-1	5950-01-094-7439	TMO9-1	5950-01-141-0174
TMO1-1	5950-01-178-2612	TMO16-1	5950-01-138-4593

TC

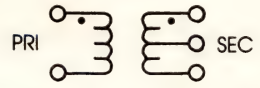
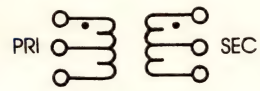
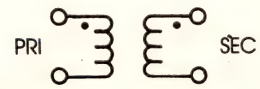
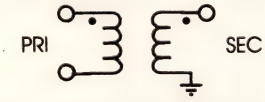
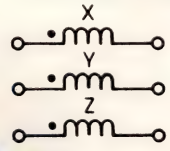
finding new ways...
setting higher standards

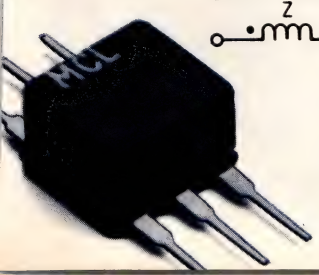
Mini-Circuits

A Division of Scientific Components Corporation
P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500
Fax (718) 332-4661 Domestic and International Telexes: 6852844 or 620156

FORMERS

3KHz-800MHz from $3.25

case style number see opposite page		MODEL NO.	Ω RATIO	FREQUENCY MHz	INSERTION LOSS 3dB MHz	INSERTION LOSS 2dB MHz	INSERTION LOSS 1dB MHz	PRICE $ Qty. (1-9)
A* 	T	T1-1T	1	.05-200	.05-200	.08-150	.2-80	4.45
		T1-6T	1	.003-300	.003-300	.01-150	.02-50	6.95
		T2-1T	2	.07-200	.07-200	.1-100	.5-50	4.95
		T2.5-6T	2.5	.01-100	.01-100	.02-50	.50-20	4.95
		T3-1T	3	.05-250	.05-200	.1-200	.5-70	4.95
		T4-1	4	.2-350	.2-350	.35-300	2-100	3.25
		T4-6T	4	.02-250	.02-250	.05-150	0.1-100	4.45
		T5-1T	5	.3-300	.3-300	.6-200	.5-100	4.95
		T8-1T	8	.03-140	.03-140	.10-90	1-60	7.95
		T13-1T	13	.3-120	.3-120	.7-80	5-20	4.95
		T16-6T	16	.03-75	.03-75	.06-30	.1-20	5.65
	TH	T4-1H	4	10-350	10-350	15-300	25-200	5.95
	TMO	TMO1-1T	1	05-200	.05-200	.08-150	.2-80	7.95
		TMO2-1T	2	.07-200	.07-200	.1-100	.5-50	8.45
		†TMO2.5-6T	2.5	.01-100	.01-100	.02-50	.05-20	8.45
		†TMO3-1T	3	.05-250	.05-250	.1-200	.5-70	7.95
		TMO4-1	4	.2-350	.2-350	.35-300	2-100	6.25
		TMO5-1T	5	.3-300	.3-300	.6-200	5-100	8.45
		TMO13-1T	13	.3-120	.3-120	.7-80	5-20	8.45
B* 	TT	TT1-6	1	.004-500	.004-500	.02-200	.1-50	6.95
		TT1.5-1	1.5	.075-500	.075-500	.2-100	1-50	5.95
		TT2.5-6	2.5	.01-50	.01-50	.025-25	.05-10	6.45
		TT4-1	3	.05-200	.2-50	.2-50	1-30	5.95
		TT4-1A	4	0.1-300	0.1-300	0.2-250	0.3-180	6.95
		TT25-1	25	.02-30	.02-30	.05-20	.1-10	9.95
	TTMO	TTMO25-1	25	.02-30	.02-30	.05-20	.1-10	11.95
		TTMO1-1	1	.005-100	.005-100	.01-75	.05-40	11.45
		TTMO4-1A	4	0.1-300	0.1-300	0.2-250	0.3-180	13.95
C 	T	T1-1	1	.15-400	.15-400	.35-200	2-50	3.25
		T1.18-3	1.18	0.01-250	0.01-250	0.02-200	0.03-50	5.65
		T1-6	1	.01-150	.01-150	.02-100	.05-50	5.65
		T1.5-1	1.5	.1-300	.1-300	.2-150	.5-80	4.45
		T1.5-6	1.5	.02-100	.02-100	.05-50	0.1-25	5.65
		T2.5-6	2.5	.01-100	.01-100	.02-50	.05-20	4.45
		T4-6	4	.02-200	.02-200	.05-150	.1-100	4.45
		T9-1	9	.15-200	.15-200	.3-150	2-40	3.95
		T16-1	16	.3-120	.3-120	.7-80	5-20	4.45
		T36-1	36	.03-20	.03-20	.05-10	.1-5	6.95
	TO	TO-75	1	10-500	—	10-500	40-250	6.95
	TH	T1-1H	1	8-300	8-300	10-200	25-100	5.95
		T9-1H	9	2-90	2-90	3-75	6-50	6.45
		T16-H	16	7-85	7-85	10-65	15-40	6.45
	TMO	TMO1-02	1	1-800	1-800	2-500	—	9.45
		TMO1-1	1	.15-400	.15-400	.35-200	2-50	6.25
		TMO1.5-1	1.5	.1-300	.1-300	.2-150	.5-8	8.45
		†TMO2.5-6	2.5	.01-100	.01-100	.02-50	.05-20	7.95
		†TMO4-6	4	.02-200	.02-200	.05-150	.1-100	7.95
		TMO6-1	6	.3-200	.3-200	.5-150	5-50	7.95
		TMO9-1	9	.15-200	.15-200	.3-150	2-40	7.95
		TMO16-1	16	.3-120	.3-120	.7-80	5-20	7.95
D 	T	T2-1	2	.050-600	.050-600	.1-400	.5-200	3.95
		T3-1	3	.5-800	.5-800	2-400	—	4.45
		T4-2	4	.2-600	.2-600	.5-500	2-250	3.95
		T8-1	8	.15-250	.15-250	.25-200	2-100	3.95
		T14-1	14	.2-150	.2-150	.5-100	2-50	4.95
	TMO	TMO2-1	2	.050-600	.050-600	.1-400	.5-200	7.95
		TMO3-1	3	.5-800	.5-800	2-400	—	8.45
		TMO4-2	4	.2-600	.2-600	.5-500	2-250	7.95
		TMO8-1	8	.15-250	.15-250	.25-200	2-100	7.95
		TMO14-1	14	.2-150	.2-150	.5-100	2-50	8.45
	FT	FT1.22-1	1.22	.005-100	.005-100	.01-50	.05-25	35.95
		FT1.5-1	1.5	.1-400	.1-400	5-200	1-100	35.95
E 	FTB	FTB-1	1	.2-500	.2-500	.5-300	1-100	36.95
		FTB1-6	1	.01-125	.01-125	.05-50	.1-25	36.95
		■FTB-1-75	1	.5-500	.5-500	5-300	10-100	36.95
F 	T	T-622	1	0.1-200	0.1-200	0.5-100	5-80	3.25
		T626	1	0.01-10	0.01-10	0.2-5	.04-2	3.95



■ Denotes 75 ohm models

* FOR A AND B CONFIGURATIONS

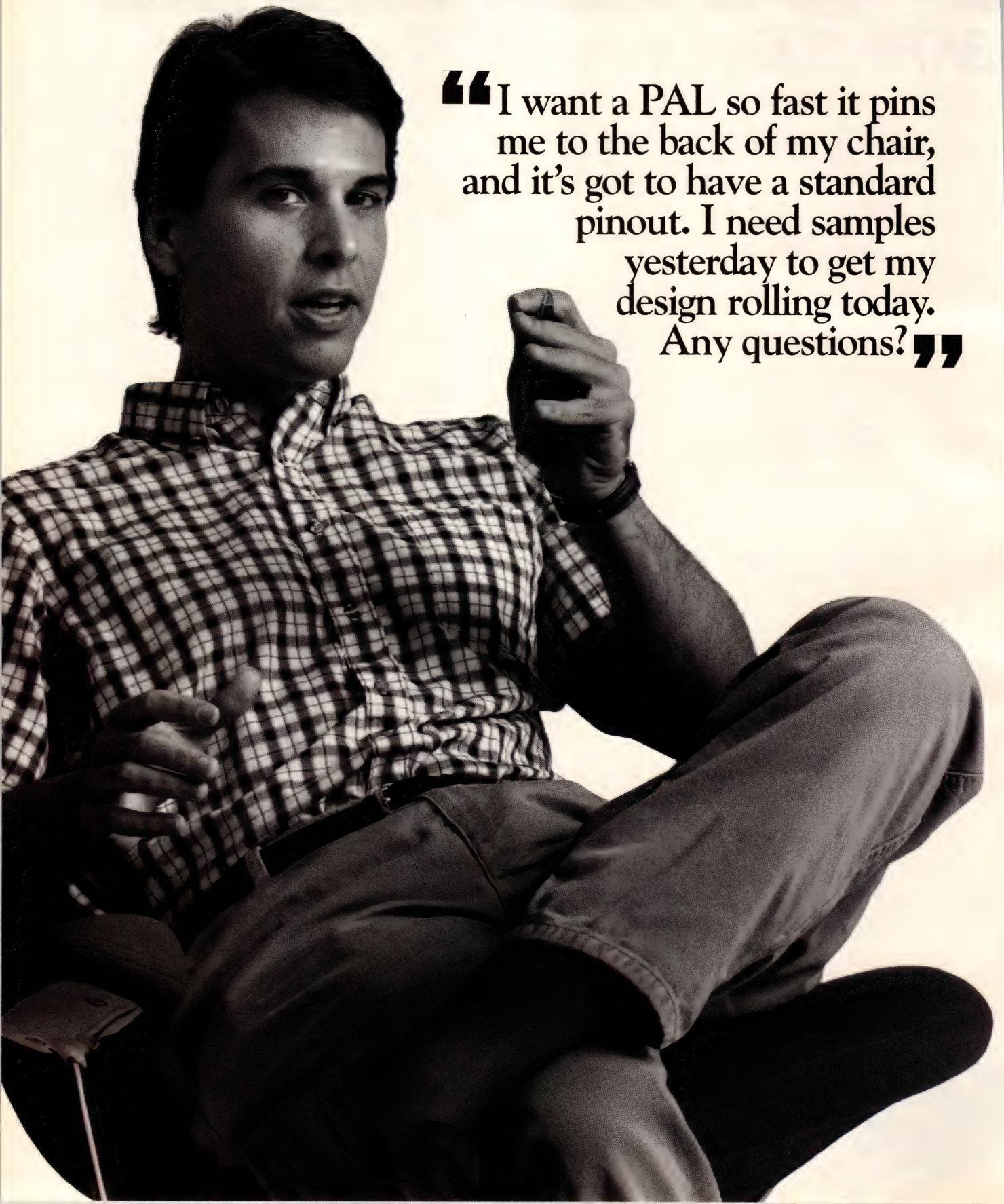
Maximum Amplitude Unbalance
0.1 dB over 1 dB frequency range
0.5 dB over entire frequency range

Maximum Phase Unbalance
1.0° over 1 dB frequency range
5.0° over entire frequency range

CIRCLE NO. 29

IN THE ERA OF MegaChip™ TECHNOLOGIES

ASIC SOLUTIONS:



"I want a PAL so fast it pins me to the back of my chair, and it's got to have a standard pinout. I need samples yesterday to get my design rolling today. Any questions?"

5-ns PALs

Texas Instruments introduces the world's first 5-ns TTL PAL® device in a standard pinout. At 5 ns these new PALs break the speed barrier while remaining within the familiar JEDEC-standard PAL pinout. To get your design off to a fast start, just call us and we'll send you the information you need to begin your evaluations.

Matching fast CPU speeds

Operating at 125 MHz, our 5-ns PALs enable you to take greater advantage of advanced microprocessor speeds. Our new PAL incorporates an innovative chip design, but it is fabricated in the reliable IMPACT-X™ bipolar process to which you are accustomed. Just design them in.

Simple upgrades

You can easily boost the performance of your present systems with these new superfast PALs. They come in 20- and 24-pin industry-standard footprints that fit right into your present system, allowing pin-for-pin replacements.

Superfast and superquiet

In addition to 5-ns speed, you get less noise than in standard 7-ns PAL devices. In fact, groundbounce has been reduced by 21%.

Adding to our comprehensive PLD family

TI's broad family of programmable logic devices (PLDs) includes PALs that offer a choice of speeds from 5 ns to 25 ns in both latched and registered configurations:

20-pin Devices	24-pin Devices
TIBPAL16L8-XX	TIBPAL20L8-XX
TIBPAL16R8-XX	TIBPAL20R8-XX
TIBPAL16R6-XX	TIBPAL20R6-XX
TIBPAL16R4-XX	TIBPAL20R4-XX

XX is the speed designator; from 5 ns to 25 ns.

All are available in plastic DIPs and PLCCs. We offer military versions, too.

Two easy ways to program TI PALs

Programming our 5-ns PALs is simple and quick. You can program them yourself, using your choice of third-party equipment. Or, if you prefer, your local TI distributor can handle the programming for you.

For more information on the PAL that breaks the speed barrier, call us

We'll send you information on our new 5-ns PAL as well as data on our entire family of programmable logic devices. Call us: Japan 81-3-769-8700; Singapore 65-251-9818; Hong Kong 852-735-1223; Australia 61-2-887-1122.



™ MegaChip, IMPACT (*Implanted Advanced Composed Technology*), and IMPACT-X are trademarks of Texas Instruments Incorporated.
® PAL is a registered trademark of Monolithic Memories, Inc.

©1990 TI

08-0105B1

TEXAS INSTRUMENTS



Your Design Goes Through A Lot Of Phases Before It's Wrapped Up.

Right from the beginning...

First design to end product can be a long haul. As market windows keep getting smaller and smaller, you need to get through the design cycle even faster.

But, no matter what stage of design you're in, Mitsubishi's got your ROM needs covered. And, we'll help you cover them quickly and cost-effectively.

During design, prototyping and pre-production, when reprogrammability is critical, Mitsubishi offers traditional CERDIPs, from 256K through 4 Meg. And, we help reduce development costs, time and frustrations in surface-mount designs with 1 and 2 Meg, windowed ceramic-leaded-chip-carriers (CLCC).

For cost-effective volume production, Mitsubishi offers one-time programmable ROMs from 256K through 2 Meg in DIP, flat pack and PLCC packages. If you require exceptionally high memory density, especially in portable applications, we've got 256K, 1 and 2 Meg OTP ROMs in thin-small-outline-packages (TSOP). The TSOP lets you pack more memory on board,



And We Have EPROM Packages And Speeds To Match Every Design.

since it is less than half the size of the equivalent pin-count, standard surface-mount package.

When your volume production codes are stabilized, we've got high density, 4 Meg mask programmable ROMs in DIP, flat pack and TSOP packages.

Before you wrap up any phase of your design, in fact, before you even start your design, give Mitsubishi a call. We're ready with the right EPROM at the right time. (408) 730-5900, ext. 2106.

	64K	256K	512K	1 Meg	2 Meg	4 Meg
EPROM		85 ns CERDIP	100 ns CERDIP	120 ns CERDIP, CLCC	100 ns CERDIP, CLCC	120 ns CERDIP
OTP ROM		100 ns PDIP, SOP, TSOP	120 ns PDIP, SOP	150 ns PDIP, PLCC, SOP, TSOP	120 ns PDIP, PLCC, SOP, TSOP	150 ns PDIP
MASK PROGRAMMABLE ROM						150 ns PDIP, SOP, TSOP
EEPROM	150 ns PDIP, SOP, TSOP					

Access times indicated are fastest available.
CLCC = Windowed Ceramic-Leaded-Chip-Carrier
TSOP = Thin-Small-Outline-Package; also available in reverse pin-out.

MITSUBISHI ELECTRONICS

Regional Sales Offices:
NORTHWEST (408) 730-5900
SOUTHWEST (213) 515-3993
SOUTH CENTRAL (214) 245-0047
NORTHERN (612) 938-7779
NORTH CENTRAL (708) 298-9223
NORTHEAST (617) 932-5700
MID-ATLANTIC (201) 469-8833
SOUTH ATLANTIC (919) 460-0404
SOUTHEAST (407) 487-7747

District Sales Offices:
SAN DIEGO (619) 451-9618
DENVER (303) 740-6775

Authorized Canadian Distributors:
Mitsubishi Electric Sales Canada, Inc.
Toronto /Calgary/Winnepeg/Vancouver/London (416) 670-8711
Ottawa/Montreal/St. Laurent/Bellville (613) 591-3348

WHEN YOUR REPUTATION'S ON THE LINE.



For superior battery performance, reliable enough to risk your reputation on, specify Rayovac.

For quality in the long run, consider our 844 Computer Clock Battery. Its unique architecture delivers economical long life and safe, reliable operation.

Our Lifex Lithium Coin Cells offer a shelf life ten times longer than conventional crimp seal batteries. With greater capacity retention and superior performance. They're available in a variety of tab and pin configurations.

For reliability in harsh environments, consider our Lifex FB batteries. Encapsulated cell technology allows them to withstand humidity, thermal shock and temperatures from -40°C to +100°C.

To set your ideas into motion, call your distributor. And tap into the power of innovation at Rayovac.

RAYOVAC®

The power of innovation.

Newark Electronics	Sager	Hammond/EMSCO	Cypress Electronics	Marsh Electronics
Locations Worldwide	1 617 749-6700	1 407 849-6060	1 408 980-2500 1 800 538-5112 outside CA	1 414 475-6000

© 1989 Rayovac Corporation

CIRCLE NO. 31

EDITORIAL

Communicate or perish



I've written about communications several times and because of a recent experience, it's time to write about it again. We just heard from an engineer who was struggling to get a new DRAM (dynamic RAM) chip from a foreign supplier to operate in his design. Try as he might, the chip would not operate in its static-column mode. Out of frustration, our friend called the supplier and told an applications engineer that the part wasn't working. The poor applications engineer was caught between an angry customer and a resolute company that insisted that its parts did work. To prove it, they sent our engineer a photo showing that the chip did operate properly—in the company's test fixture.

It turns out that, even after repeated requests, the supplier never sent our engineer a complete data sheet. Instead, the applications engineer sent him the first five pages of the part's data sheet via fax. The supplier has a rule that applications people can send only five fax sheets per day to a given customer location. Unfortunately, the applications engineer never followed up by sending the complete data sheet by mail. Worse, he sent our engineer two sets of incomplete and *conflicting* data via fax. Apparently there was a problem translating the data sheet into English, but neither set of information told which were the correct specs.

In the end, our engineer friend used a top-of-the-line logic analyzer to catch the memory chip acting up. He found the problem, and it was in his design, not in the chip. But without all the timing information, it was impossible to design his control circuit to work properly the first time. He felt, quite rightly, that instead of support, all he got from the supplier was whitewash.

I'm sure glad that no US-based companies act like the supplier above when they do business in foreign countries. But it still might be worth an audit of how your company—and you—communicate with customers. Does your company have silly rules and regulations that limit access to fax machines, express mail, and other vital communications services? If it does, then figure out how to change the rules. If you can't change them, here are some ways to circumvent them:

If multipage fax transmissions are a problem, send some pages from a different fax machine. Say yours is broken or jammed. If you don't have an alternate fax machine, break your transmissions into authorized bundles, and send them all. Say the first few didn't go through or the recipient's machine ran out of paper.

If you can't send mail by overnight or express delivery, ask the mailroom to send them by surface carriers that offer next-day delivery, such as UPS. Some rule watchers don't know that overnight and next day are basically the same thing. Better yet, wrap the information around some parts or chips and send the package air express marked "samples."

It's sad that we have to use our imaginations to keep in touch with customers, but we must keep in touch at any cost. Unfortunately, when we get caught circumventing communications roadblocks, we get punished—not the people who put up the roadblocks in the first place.



Jesse H Neal
Editorial Achievement Awards
1987, 1981 (2), 1978 (2),
1977, 1976, 1975
American Society of
Business Press Editors Award
1988, 1983, 1981



Jon Titus
Editor

BEFORE YOU CHOOSE P
BETTER CHECK



Things aren't always what they seem.

Some people would have you believe FPGAs are faster and denser than MAX™ EPLDs.

Funny how they never mention *in-system* performance, though. When they talk about speed, they quote 100MHz flip-flop toggle rates. When they talk about density, they recite raw gate counts.

Which could make your high-performance design highly disappointing.

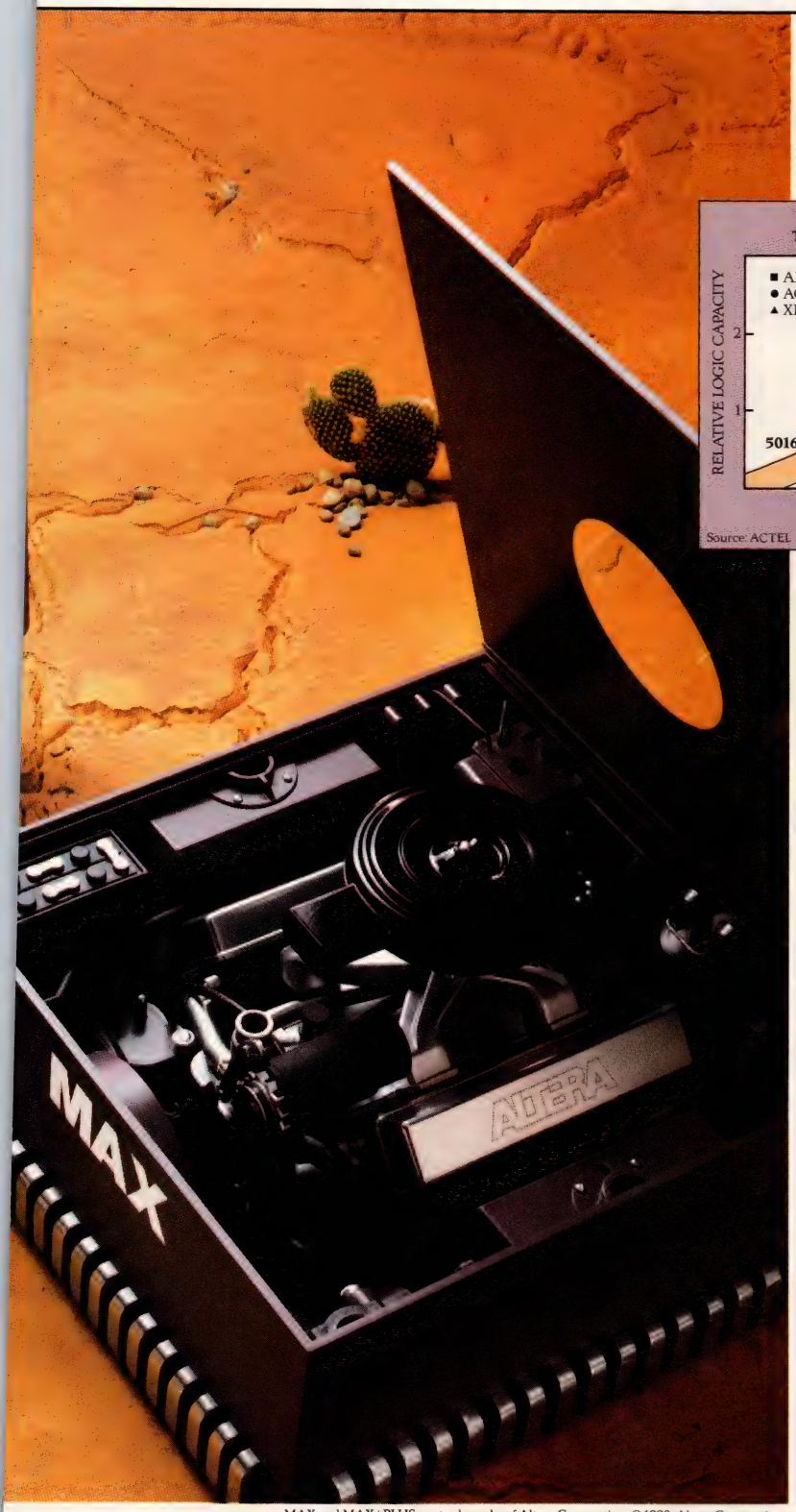
But if you want to do more than just spin your wheels, consider MAX.

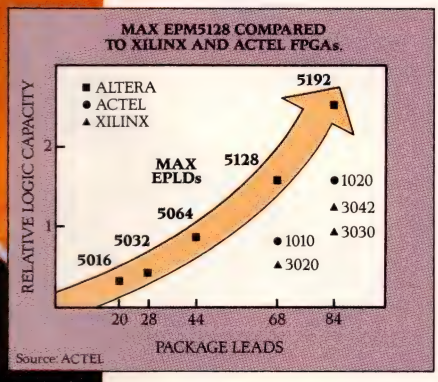


It's the first family of programmable logic devices to provide both high speed and high logic density where it counts. At the system level.

Which means MAX can handle just about all your logic needs. In fact, a single 64-macrocell EPM5064

ROGRAMMABLE LOGIC, UNDER THE HOOD.





can integrate anything from simple system glue logic right up to complex graphics coprocessors and LAN and memory controllers.

Or take the 68-pin MAX EPM5128. It's up to 50% faster and 100% denser than comparable FPGAs, thanks to its high-performance architecture and superior logic routability. But don't take our word for it—just take a look at the competition's benchmarks.

Best of all, MAX gives you this unbeatable performance in record time. With powerful, easy-to-use MAX+PLUS™ software, design compile times are measured in minutes. Not hours or days.

So if you're looking to redefine system performance, talk to the folks who invented the EPLD. Call Altera today at (408) 984-2800.

We'll make sure you've got plenty of horses under the hood.

ALTERA

2610 Orchard Pkwy., San Jose, CA 95134-2020
Tel. (408) 984-2800 Fax. (408) 248-6924

MAX and MAX+PLUS are trademarks of Altera Corporation. © 1990, Altera Corporation.

It's 1992. Do you know where your 4-meg DRAMs are?



NEC customers have no cause for alarm.

©1990 NEC Electronics Inc.

The best way to feel good about future DRAM supplies is to buy from NEC today.

Many experts expect DRAM shortages by 1992. Naturally, these predictions make buyers nervous.

At NEC, we take these worries seriously. We're planning ahead now to keep our long-term customers supplied now, and in the future.

That's why we're putting $400 million more into our Roseville fab. Located on 72 acres near Sacramento, California, this wafer fabrication plant has been in volume production since 1984.

NEC was the first Japanese company to invest heavily in U.S. manufacturing. We're already shipping over five million low-cost, high-quality integrated circuits per month, direct from Sacramento to you.

U.S. Memories, Microprocessors, and ASICs too.

The first 4-meg DRAMs made in the United States will be made by NEC. In fact, our new submicron line will add another five million new units per month by the spring of 1992.

If you are buying 256K DRAMs from us now, you know our American products are of the same unsurpassed quality as our 1-meg and 4-meg DRAMs made in Japan and other worldwide locations.

Our U.S. fab is growing to five times its current size. Soon, we'll be able to meet all your future needs with American-made versions of our most advanced DRAMs, SRAMs, VRAMs, microprocessors and ASICs.

The time is now.

Whatever your IC needs, you can put our local manufacturing clout to work for you immediately.

NEC's California fab already offers ASIC designers the same uncompromising quality found in our standard products along with an important bonus: hands-on local control of production.

Our customers remain loyal to us, because we are loyal to them.

Call 1-800-632-3531 today to learn more about doing business with NEC, your global manufacturing partner. Our complete line of microprocessors, ASICs and memory products is available now.

For even faster service, FAX your literature request to 1-800-729-9288. Ask for Info Pack 393.





Our expanding California facility will produce the first 4-meg DRAMs made in America.

NEC Electronics Inc.
401 Ellis Street
Mountain View, CA
94039-7201
1-800-632-3531/415-965-6158

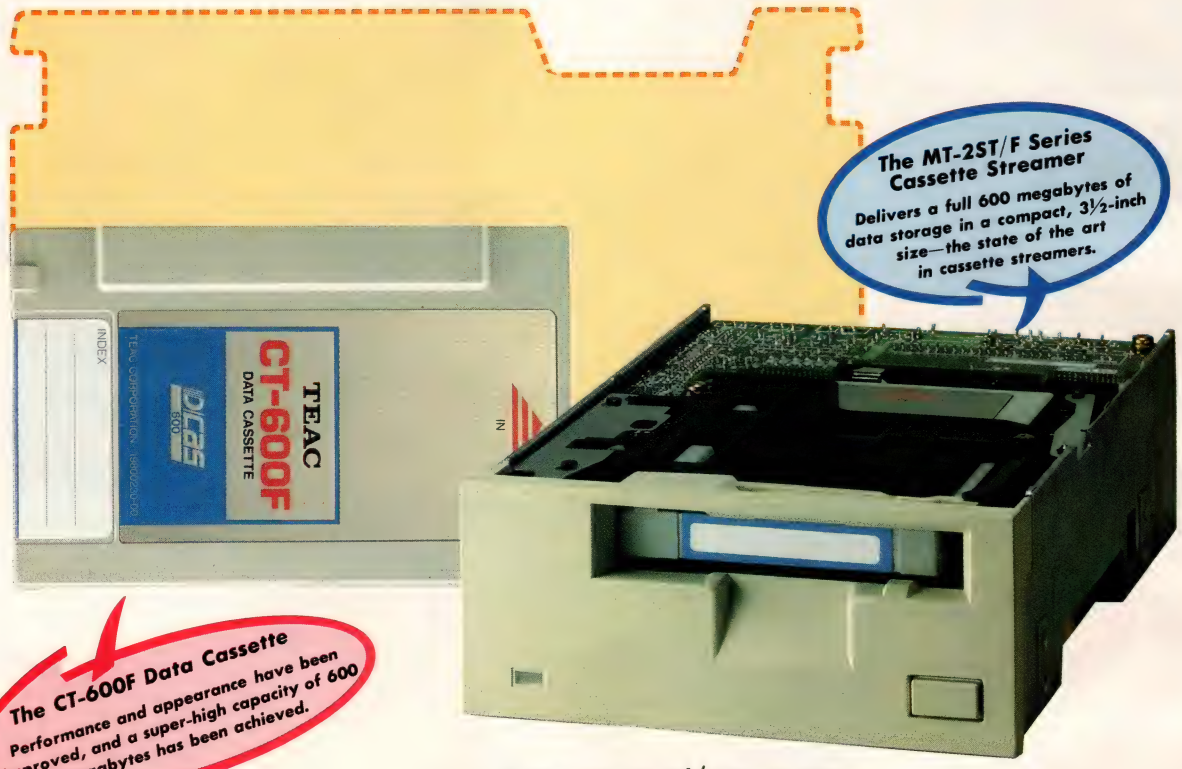
NEC

CIRCLE NO. 33

STREAMERS FOR SCREAMERS!

TEAC®

SMALL IN SIZE (3½ INCH FORM FACTOR).
HUGE IN CAPACITY (A FULL 600MB).



- Compact 3½-inch size.
- High-speed data transfer: 242.3KB/sec.
- A choice of interfaces: SCSI or D/CAS-5.
- Autoeject function.
- 5¼-inch form factor models also available.

3½-inch Form Factor Cassette Streamer

MT-2ST/F SERIES

For Memories You'll Be Glad To Have

TEAC CORPORATION Musashino Center Bldg., 1-19-18 Naka-cho, Musashino, Tokyo 180, Japan Tel:0422-52-5041 Telex:34435 Fax:0422-55-2554

■**Hong Kong,** Nissei Sangyo Co., Ltd. Hong Kong Branch Tel: 3-343441-6; KARIN ELECTRONIC SUPPLIES CO., LTD. Tel: 3-898252 ■**Singapore,** NISSEI ELECTRONICS, LTD. SINGAPORE BRANCH OFFICE Tel: 2357900; UAC SINGAPORE REP. OFFICE Tel: 2922608 ■**New Zealand,** DATAMATIC NETWORKS LIMITED Tel: 09-444-0760 ■**Australia,** AWA DISTRIBUTION Tel: 02-888-9000 ■**Indonesia,** CHUGAI BOYEKI CO., LTD. Tel: 370824 ■**Philippines,** COMPEX INTERNATIONAL INC. Tel: 213020 ■**India,** Priya Electronics & Chemicals Limited Tel: 2863611 ■**Kuwait,** Bader Al Mulla & Brothers Co. W.L.L. Tel: 2423250 ■**United Kingdom,** TEKDATA LIMITED Tel: 0782 577677; Data Peripherals (UK) Limited Tel: 0785 57050 ■**F.R. Germany,** nbn Elektronik GmbH Tel: 08152/390 ■**Austria,** nbn Elektronik GmbH Tel: 0316/40 28 05 ■**Netherlands,** SIMAC DATA B.V. Tel: 040-582933 ■**Belgium & Luxemburg,** SIMAC ELECTRONICS SPRL/BVBA Tel: 02/252.36.90 ■**France,** TEKELEC AIRTRONIC S.A. Tel: (1)4534-75-35 ■**Italy,** A.E.S.S.E. S.p.A. Tel: 02/54.64.741 ■**Spain,** ATAIO INSTRUMENTOS S.A. Tel: 735-0252 ■**Portugal,** BASF PORTUGUESA LDA. Tel: (351) 1-562511 ■**Switzerland,** WENGER PERIPHERALS AG Tel: 01/830 75 55 ■**Denmark,** Dansk Binaer Teknik A/S Tel: 03/66-20 20 ■**Sweden,** MACROTEK AB Tel: 08-733 02 20 ■**Norway,** SCANTELE A/S Tel: (02)65 69 20 ■**Finland,** INSTRUMENTARIUM CORPORATION Tel: 90-528 4338

**If no distributor listed above is in your area, please contact us directly for further details about our products.*

Prototyping ASICs makes design less risky



The time-honored art of prototyping circuit designs can also benefit ASIC designs. Programmable logic and in-circuit emulators are among the prototyping tools available.

Richard A Quinnell,
Regional Editor

One of the biggest deterrents designers face when considering an ASIC design is the high cost of failure, both in money and in time. You can improve your chances of having a successful design by prototyping your ASIC. But first, plot out your migration path from prototype to ASIC. Otherwise, you may wind up paying the very penalties you hoped to avoid.

When ASICs first became available, your only prototyping alternative was wiring your design in discrete logic. That method was feasible for devices with 100 to 200 gates, but quickly became a burden for larger designs. You spent more time fixing prototype implementation errors than actual design errors.

Simulation replaced prototyping for many designs, but simulation has its own limitations. For one thing, a successful circuit simulation doesn't guarantee that the circuit will perform properly in your system. System-level simulators address that concern, but some parts of the system aren't readily simulated. Electromechanical components, such as magnetic heads and field coils in disk drives, are major challenges for system simulators.

For another thing, simulations are only approximations based on mathematical models. Those models are fairly reliable for digital circuits, but analog-circuit simulations can sometimes have unexpected results (**Ref 1**). Most designers treat simulation results with a healthy dose of skepticism.

Prototyping your IC adds a measure of confidence in your design that simulation can't provide. There are a number of available methods for prototyping digital circuits. These methods depend on the size of your design. For designs of 100- to 200-gate complexity, you could still use discrete logic, if you're a masochist. Programmable logic devices, on the other hand, allow you to easily prototype designs of 1000-gate complexity.

FPGAs (field-programmable gate arrays) are even more complex. They allow you to prototype in a single device a design requiring several thousand gates. If your entire design will fit into a single FPGA, you gain more than confidence. You can use the programmable part for early production, keeping the ASIC's development out of the critical



Simulating mixed analog-digital ASICs in circuit, *the Plessey PDM allows you to test your design before committing it to silicon. The PDM combines your analog breadboard with reprogrammable logic to mimic your design.*

LTL 2000.™ Just one way *ISS* listened to your design needs



If the ISS LTL 2000 Design System sounds like an IC designer's ideal, it's because we listened to IC designers when we developed it.

We heard customers like you tell us about your IC design challenges. With your inputs, we created LTL 2000—the *designer's solution* for advanced layout, rules checking and user programmability.

LTL 2000 Design System is a suite of integrated EDA tools that includes:

- **LTL-100™ Layout Editor**, the industry's most powerful IC layout system that allows quick and efficient editing at all levels of chip hierarchy
- **LRC-100™ Layout Rules Checker**, capable of executing interactive checks during layout for even the most complex designs
- **CPI-100™ C Programming Interface**, that allows easy access to the LTL 2000 design environment

The LTL 2000 design system operates on leading UNIX and DOS platforms, including Sun,™ Apollo™/HP or 386/486-based workstations.

Try the LTL 2000 System free for 30 days — Install it on the workstation of your choice, or visit our sales offices for a demonstration. See for yourself how well we listened.



To hear more about the LTL 2000, call us toll free at **1-800-4-CAD-LTL**

See us at DAC Booth 1847

ISS Integrated Silicon Systems, Inc.

ISS. The IC CAD company that listens.

P.O. Box 13665, Research Triangle Park, NC 27709, 919/361-5814 California: 408/562-6154 Texas: 512/452-5814

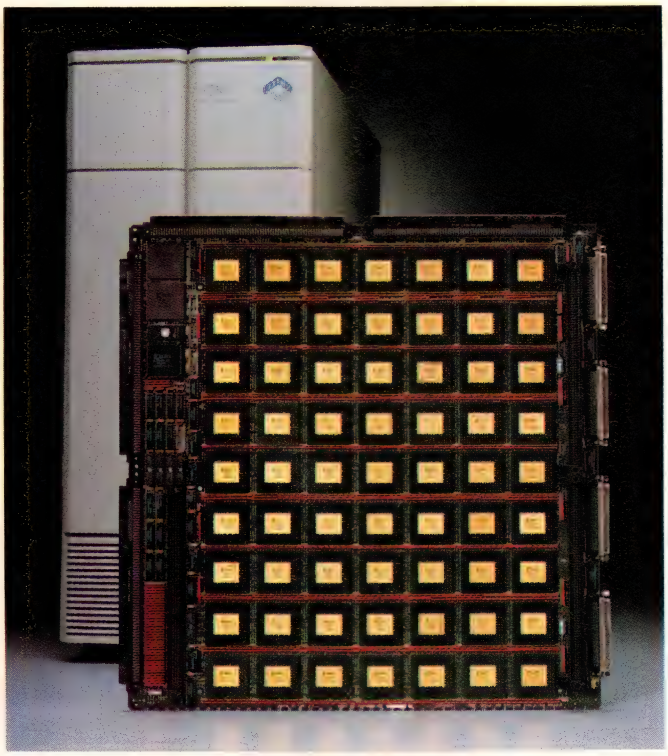
UNIX is a trademark of AT&T. Apollo is a trademark of Apollo Computer. Sun is a trademark of Sun Microsystems, Inc.

Prototyping ASICs

path for product introduction. You may even choose not to bother with an ASIC (see **box**, "Ship the prototype").

Prototyping does build confidence in your design before you commit it to silicon; it does not necessarily save you money. Unless you understand how your prototype migrates to an ASIC, you could spend a lot of time debugging your prototype, and then still wind up paying for multiple iterations of your ASIC to fix errors introduced during the conversion.

Two factors characterize a design: function and timing. A prototype will allow you to verify your design's function, but the design's timing will change when you change implementation technology. Accounting for those changes is key to a successful migration from prototype to ASIC.



You can emulate digital ASICs as large as 50,000 gates *with the RPM System Emulator from Quickturn Systems. The RPM accepts designs in a number of ASIC library formats.*

Speed is perhaps the most obvious difference between a prototype and an ASIC. Gate arrays are typically faster than programmable parts, so don't count on minimum gate delays in your design. Synchronous designs have the greatest chance of converting without timing errors.

Not so obvious as speed differences is the fact that your circuit's structure will change during the conversion. The change occurs because of differences in the way logic is implemented in gate arrays and in programmable devices.

Structural differences

You would expect PLDs and gate arrays to have different logic structures. With the name field-programmable gate array, however, it's easy to assume that an FPGA and a mask-programmed gate array are structurally similar. The logical conclusion is that your design will map into similar circuits on the two devices. Not necessarily. The two device types are actually quite different structurally. FPGAs typically consist of an array of logic blocks with programmable interconnects. The blocks are moderately complex circuits, typically containing both combinatorial logic and a flip-flop (**Refs 2** and **3**). A mask-programmed gate array, on the other hand, is simply an array of uncommitted gates.

The structural differences manifest themselves when you try to convert your programmable design to a gate array. There is seldom a correspondence between the CAD library macrocells you designed with and the ones you're converting to. You must first break down the design into its component gates. The Actel ACT family is an exception, however. It has only combinatorial logic in its logic blocks. As a result, the Actel macrocell library is very similar to that of a gate array. The similarities are close enough that some designs can be converted simply by using a word processor to change macrocell names in the net list.

Fortunately, several companies have automated the more involved conversion process for PLDs and other FPGAs. Gould/AMI, for example, offers a translation service, PALtrans, for designers wanting to use its gate arrays. **Fig 1** shows the steps used by PALTRANS; the steps are typical for automated conversions.

The first step in converting your design is to "flatten" it. That is, reduce it to its component logic. Then, logic-synthesis software creates a new net list. Circuit-optimization software removes the unnecessary logic, such as extra registers and gates wired in parallel, to accommodate the timing and drive characteristics of your prototyping device. Simulation software then checks that the new circuit's behavior matches your test vectors.

It's in this checking step that the automated process breaks down. The metamorphosis your design undergoes is bound to introduce timing changes. You must resolve any conflicts that arise, and your test vectors are the key components in helping you do just that. Delyle Danner, chief engineer at Arnav Systems (Portland, OR) and a vet-

Prototyping ASICs

eran of several prototype-to-ASIC conversions, says that only the test vectors caught subtle timing errors on several conversion projects, saving his company the NRE charges for second iterations.

Creating adequate test vectors gave Danner another benefit. He was able to turn his conversion projects completely over to the ASIC vendor. Danner was called in only to resolve the timing conflicts. Though this hand-off of responsibility cost him the first-silicon success he enjoyed when he handled the conversion himself (the vendor-handled conversions required one iteration each), it freed him to work on new projects. Because programmable devices were usable in production until the ASIC was ready, the iterations didn't impact his product's introduction.

Several companies offer automated conversion processes similar to Gould/AMI's. Harris Semiconductor offers a conversion, with normal NRE charges, from designs based on Xilinx XC2000 or XC3000 FPGAs to Harris' CGA200 gate arrays or its HSC4000 standard-cell ASICs. Integrated Logic Systems Inc (ILSI) will automatically produce pin-for-pin replacements for programmed Actel, Altera, or Xilinx FPGAs for as little as $5000 in NRE charges. The ILSI gate array also has scan-based test circuitry.

Other ASIC vendors will likely follow suit with links to prototypes. Texas Instruments, for example, is developing a migration path from its FPGAs to its gate arrays that uses schematic-level design information instead of flattening the design.

Manufacturing companies are not the only ones offering conversion programs. Wyle Laboratories, a distributor for both Actel FPGAs and LSI Logic Corp gate arrays, offers an automated conversion from one to the other. DGA Associates, a distributor of IC design software, offers a no-risk conversion from Altera or Xilinx parts to an ASIC, with no up-front NRE charges. You don't pay unless you're satisfied with the result. In Europe, distributor Gothic-Crellon Ltd offers conversion from Actel FPGAs to ES2 gate arrays.

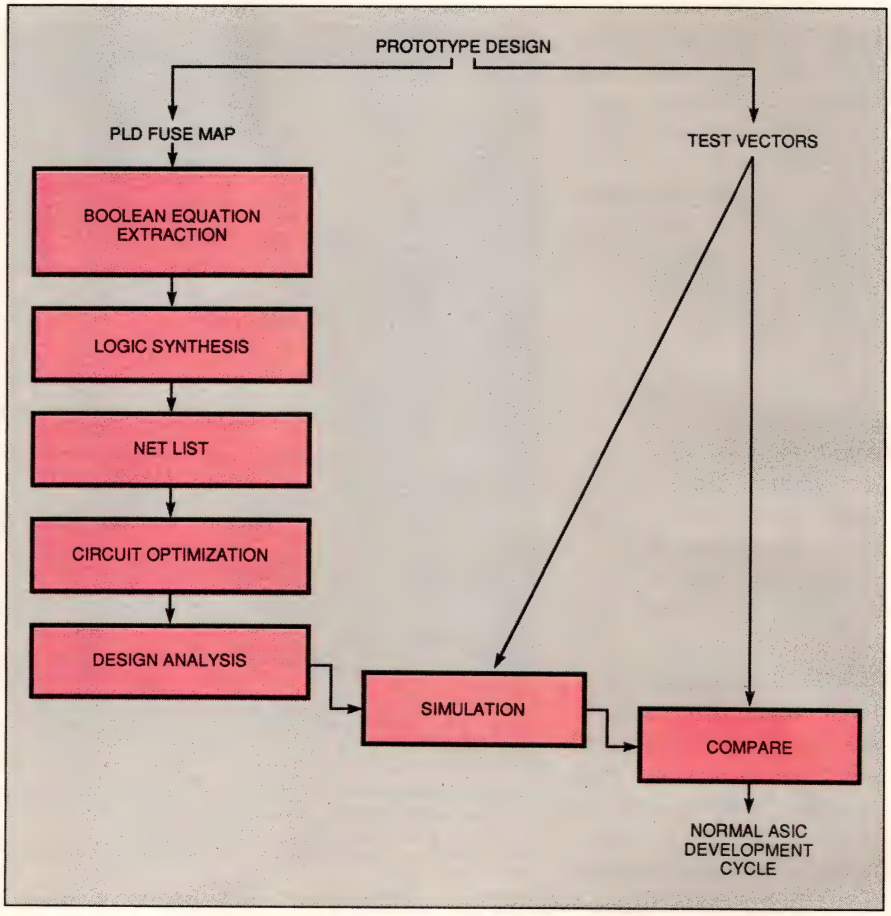


***Fig 1—Many steps are necessary to migrate from a prototype design to an ASIC**, as seen in this flow chart for Gould/AMI's PALTRANS service. Although most of the steps are automated, you will need to become involved when the comparison discovers the inevitable conversion errors.*

Using FPGAs to prototype your design is fine if your design falls within FPGAs' 9000-gate capacity. If your design gets into the 10,000+ gate category, however, fabricating your own prototype may be more of a hassle than it's worth. You wind up spending more time solving implementation problems than design problems.

An ASIC emulator, however, lets you test large ASIC designs in your system before committing to silicon. Quickturn Systems offers its RPM Emulation System with a starting price of $125,000. It plugs into your ASIC's printed-circuit-board socket and can emulate designs as large as 50,000 gates. It can run at speeds as high as 5 MHz. You don't need to perform any design conversions to use the RPM; it accepts your design as described in the ASIC vendor's format and automatically configures the emulator.

The biggest limitations of current digital prototyping techniques are speed and I/O pin count. The devices and tools available begin to hit their limit at 40-MHz clock rates, and packages larger than 144

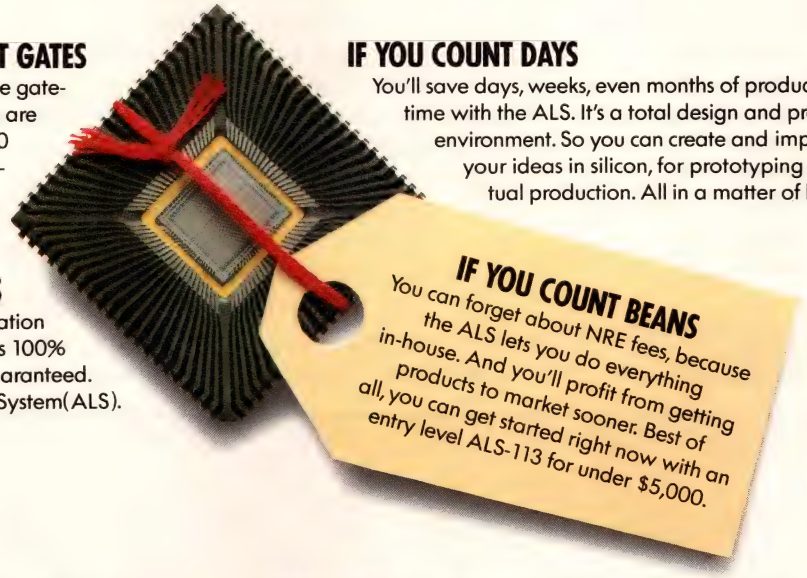
Logic Integration For People Who Count.

IF YOU COUNT GATES

You can count on the most accurate gate-counts in the industry, because our gates are counted just like full masked arrays. Our ACT 1010 has 1,200 gates, and our ACT 1020 has 2,000—the equivalent capacity of about 100 TTL parts.

IF YOU COUNT PERCENTAGES

You can count on 85% to 95% gate utilization on all your designs. Guaranteed. Plus 100% automatic placement and routing. Guaranteed. All with our Action Logic™ System(ALS).



IF YOU COUNT DAYS

You'll save days, weeks, even months of production time with the ALS. It's a total design and production environment. So you can create and implement your ideas in silicon, for prototyping or actual production. All in a matter of hours.

IF YOU COUNT BEANS

You can forget about NRE fees, because the ALS lets you do everything in-house. And you'll profit from getting products to market sooner. Best of all, you can get started right now with an entry level ALS-113 for under $5,000.

Actel Field Programmable Gate Arrays.

Start counting on Actel for the most reliable field programmable gate arrays. FPGAs that behave the way you expect. FPGAs based on the most advanced programmable logic technology available. FPGAs you design and produce yourself, with the Action Logic System (ALS) from Actel.

Entry level ALS-113 includes Viewdraw™ schematic capture software, automatic place & route and timing analysis software, and Activator 1 programmer module.

$4950.00



ACT 1 field programmable gate arrays are genuine, channeled gate arrays—not EPLDs or SRAMs masquerading as gate arrays. So they're as predictable as they are reliable.

Actel's ALS lets you use the design tools you already know, from Viewlogic,™ OrCAD,™ Mentor Graphics,™ and Valid.™ There's even an ACT 1 Macro Library of over 150 standard logic functions. And you can use the hardware you already have, like SUN™ and Apollo™ workstations, or 386 PCs.

Best of all, you can get started with an entry-level Action Logic System for less than the price of the computer it runs on.

Next time you're counting on fast, easy logic integration, count on the Action Logic System from Actel.

For more information and a free demo disk call Actel today, at **1-800-227-1817, ext. 60.**

Actel

Risk-Free Logic Integration

© 1990 Actel Corporation, 955 East Arques Ave., Sunnyvale, CA 94086. ACT, Action Logic, and Activator are trademarks of Actel Corporation. Apollo, Mentor Graphics, OrCAD, SUN, Valid, Viewdraw, and Viewlogic are all trademarks or registered trademarks of their respective manufacturers.

pins are not available. If you want the benefits of testing your ASIC in circuit, but have a design that exceeds these limits, you have no choice but to prototype in the ASIC technology you'll ultimately use for production. Getting your first device six weeks after completing its design hardly seems like prototyping, however. And a flaw in your design can wreck your schedule.

A number of companies now offer rapid prototyping services. Lasarray Corp has long been in the business of providing rapid prototypes, using a direct-write laser process to skip the step of producing a photomask. The company produces the ASIC directly on the wafer, using your net list to guide the laser beam.

Panasonic Industrial Co has created its MN59000 gate array series for those requiring rapid prototyping. The company promises to deliver devices as large as 15,000 gates within one week of post-place-and-route simulation approval.

International Microcircuits Inc (IMI) has created a separate production line dedicated to rapid prototyping. Dubbed the "Pony Express," the facility can produce full production-tested devices in as little as 10 working days. The manufacturing methods and testing performed at the Pony Express facility are identical to those used in IMI's high-volume production facility.

If you don't need quick turnaround on your prototype, but do need a very low NRE cost, try splitting the cost with other companies. By combining several ASIC designs on a single wafer, Orbit Semiconductor can provide prototypes for several customers for a single NRE charge. Shared, the NRE costs can be as little as $1500 per customer. You'll have to be patient when using this service, however, and match your project's timing to Orbit's production schedule. Orbit requires four weeks to produce your prototype. Also, the company initiates a multiproject wafer only once every six weeks.

If you have an analog or mixed analog/digital design, you may well wonder what prototyping methods are available for you. The answer, unfortunately, is few. In many cases you breadboard your designs with standard off-the-shelf components, then depend upon careful simulation to keep your ASIC design on track (**Ref 4**).

A few analog ASIC companies offer an alternative to off-the-shelf

Ship the prototype

When planning your ASIC's prototype, keep in mind that you may want to go into production with programmable devices that might not ever get to the ASIC.

There are several reasons why you might start production with programmable devices, assuming that the programmable devices meet your performance and board-size requirements. Among the most important is time to market. Rather than waiting for your ASIC's completion, a process that may require weeks of development and testing, you can begin shipping revenue-earning products right away.

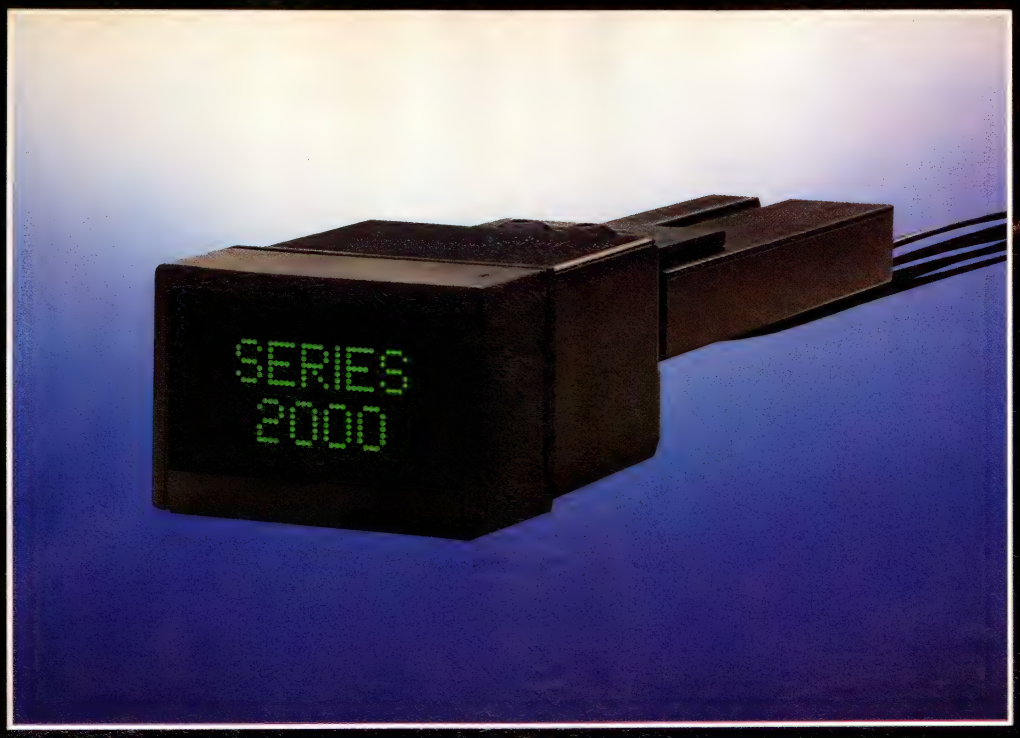
A second reason to delay the ASIC is to give yourself the ability to adapt to your customer's response. If they tell you that they'd be much happier with minor changes in the product, you won't have to go through the ASIC process a second time.

Although no one likes to admit it, there is the chance that your product may not make it in the marketplace. ASIC vendors say that as many as 80% of the ASICs designed never make it into production. You also might find that your product doesn't sell as well as you expected, in which case you don't recover the NRE costs in production savings. By holding off ASIC development until you have a proven winner, you can prevent wasting NRE money on short-lived designs.

When you do get into production, the ASIC may not save you all that much in production costs, either. If your design uses a lot of I/O pins, you may find that your ASIC is pad-limited. As a result, you must use more silicon area than the circuit requires in order to get enough I/O pads on the die. The ASIC's volume costs, therefore, could be higher than you expected.

Don't forget the other costs of changing from a programmable device to an ASIC. Changing production drawings to reflect a new component is a cost directly attributable to the design. So, too, are the costs of making space for a new part in the stockroom, of creating incoming inspection procedures, and of purchasing a reserve supply of stock from a sole source. If the ASIC is replacing several components, you have to figure in the redesign of the printed-circuit board, as well.

You may find that you're better off staying with programmable devices and shipping the product as it was prototyped.



The program in a switch.

Introducing Vivisun Series 2000, the programmable display pushbutton system that interfaces the operator with the host computer. The user friendly LED dot-matrix displays can display any graphics or alpha-numerics and are available in green, red or amber. They can efficiently guide the operator through any complex sequence, such as a checklist, with no errors and no wasted time.

They also simplify operator training as well as control panel design. Four Vivisun Series 2000 switches can replace 50 or more dedicated switches and the wiring that goes with them. In short, Vivisun Series 2000 gives you more control over everything including your costs.

Contact us today.

AEROSPACE OPTICS INC.
3201 Sandy Lane, Fort Worth, Texas 76112
(817) 451-1141 · Telex 75-8461 · Fax (817) 654-3405

SERIES

VIVISUN 2000™



Programmable display switches. Making the complex simple.

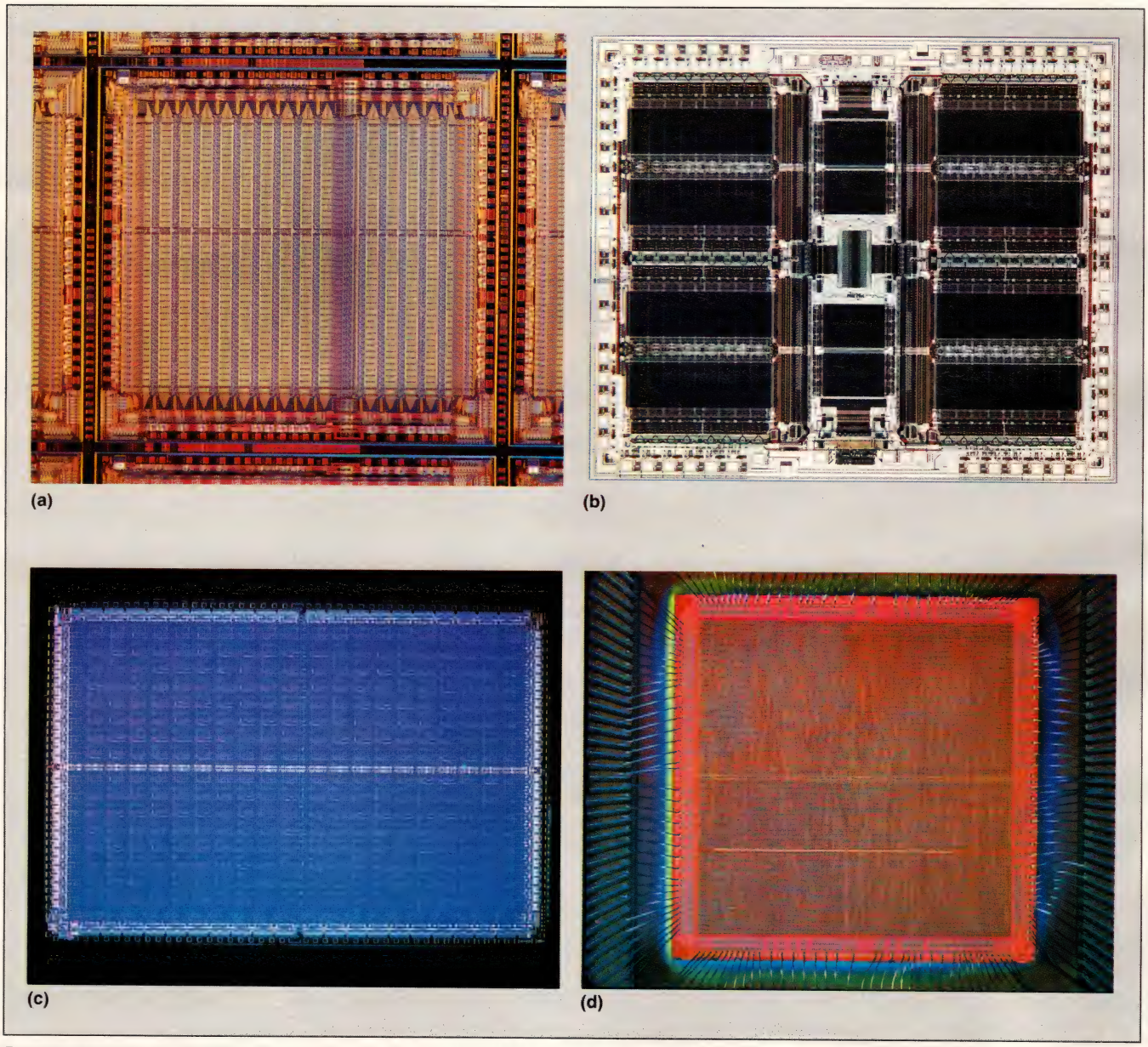
CIRCLE NO. 38

Prototyping ASICs

components for breadboarding. Advanced Linear Devices (Sunnyvale, CA), Micro Linear (San Jose, CA), and Plessey Semiconductor offer kit parts, which are parts made with the same process technology as the ASIC. Kit parts assure you that you're working within the process's limitations.

In some cases, the kit parts are actually wired-up versions of the ASIC vendor's macrolibrary entries that are not intended for mass distribution. Advanced Linear Devices takes kit parts one step further. Its kit parts and library elements are also standard, distributor-stocked products. You can, therefore, prototype your ASIC using the stock products. You can then use that prototype design in production until your ASIC is ready.

Plessey has recently expanded your prototyping options for mixed analog/digital ASICs by creating an ASIC emulator, the Plessey design modeler (PDM). The device, which costs $1500, allows you to breadboard the analog portion of your design using kit parts, then configure the digital portion in reprogrammable logic. The two portions connect to the PDM, which plugs into



Despite their name, field-programmable gate arrays (FPGAs) bear little resemblance *to true gate arrays. The FPGAs from Actel* ***(a)****, Altera* ***(b)****, and Xilinx* ***(c)*** *show varying degrees of structure; a finished gate-array design from LSI Logic* ***(d)*** *shows none.*

MORE IS MORE.
LESS IS MORE.



To many of you, our 15ns GAL22V10 is almost perfect. Which is why we designed the 28-pin **GAL26CV12** and 20-pin **GAL18V10.** These new GAL® devices repackage the familiar GAL22V10 architecture to give you the flexibility your design requires. So more and less, the GAL26CV12 and GAL18V10 make perfect sense.

All three devices offer 15ns T_{pd} using our electrically erasable E^2CMOS® technology, the fastest CMOS PLD technology anywhere. Erasability allows us to 100% test each and every GAL device, so you realize perfect programming yields, less board rework, and fewer system failures. And you can program them again and again and again...

The new GAL26CV12 and GAL18V10 from Lattice. Proof that once again, our logic makes perfect sense. For **FREE** device samples and a databook, call **1-800-FASTGAL.** Ask for Dept. 202.

Lattice
Semiconductor
Corporation™

5555 Northeast Moore Court • Hillsboro, Oregon 97124

Inventors of the E²CMOS PLD™

Copyright © 1990, Lattice Semiconductor Corporation. GAL AND E²CMOS are registered trademarks of Lattice Semiconductor Corporation.

Circle 108 for Literature

Circle 109 for Employment Information

your system so you can verify your design.

One concern in using kit parts to breadboard an analog ASIC is the effect the added packaging has on the circuit element. Kit parts have lead capacitance and inductance that are not present when the circuit element is used in the ASIC. In addition, many kit parts have circuitry that protects the part from environmental stresses such as electrostatic discharge. Such circuitry is not present in the ASIC.

Sprague Semiconductor Group is addressing this concern with its newest line of kit parts. Rather than kit parts having basic elements that the designer strings together, the Sprague kit parts are complex functions such as data separators, pulse detectors, and servo-position demodulators. Because the kit parts represent more complex building blocks, the effects of packaging contribute correspondingly less error to overall design. The Sprague kit parts currently support the most common functions encountered in rotating magnetic-storage applications.

Whether for an analog or a digital design, creating a prototype means extra work in separating design problems from implementation problems. As simulators improve both in speed and accuracy, they may very well eliminate the need to prototype ASICs; they won't eliminate the desire. Engineers tend to be conservative, and prototyping is a time-honored method for making darn sure you got it right. EDN

References

1. Conner, Doug, "Mixed analog-digital simulators are picking up speed," *EDN*, July 20, 1989, pg 160.
2. Small, Charles, "User-programmable gate arrays," *EDN*, April 27, 1989, pg 146.
3. Conner, Doug, "PLD architectures require scrutiny," *EDN*, September 28, 1989, pg 91.
4. Quinnell, Richard A, "Mixed analog-digital ASICs," *EDN*, June 22, 1989, pg 146.

Article Interest Quotient
(Circle One)
High 506 Medium 507 Low 508

For more information . . .

For more information on the prototyping products and services discussed in this article, circle the appropriate numbers on the Information Retrieval Service card or use EDN's Express Request service. When you contact any of the following manufacturers directly, please let them know you saw their products in EDN.

Actel
955 E Arques Ave
Sunnyvale, CA 94086
(408) 739-1010
FAX (408) 739-1540
Circle No. 700

Altera Corp
2610 Orchard Pkwy
San Jose, CA 95134
(408) 248-2800
FAX (408) 248-6924
Circle No. 701

DGA Associates
155 West St
Wilmington, MA 01887
(617) 935-3001
FAX (617) 270-3723
Circle No. 702

Gothic-Crellon Ltd
3, The Business Centre
Molly Millars Lane
Wokingham, Brookshire, UK
RG11 2EY
011 44 734 7888 78
FAX 011 44 734 7760 95
Circle No. 703

Gould/AMI
2300 Buckskin Rd
Pocatello, ID 83201
(208) 234-6851
FAX (208) 234-6796
Circle No. 704

Harris Semiconductor
Box 883
Melbourne, FL 32901
(407) 724-3800
Circle No. 705

Integrated Logic Systems Inc
5415 Mark Dabling Blvd
Colorado Springs, CO 80918
(719) 590-1588
FAX (719) 590-1373
Circle No. 706

International Microcircuits Inc
525 Los Coches St
Milpitas, CA 95035
(408) 263-6300
FAX (408) 263-6571
Circle No. 707

Lasarray Corp
13845 B Alton Pkwy
Irvine, CA 92718
(714) 581-0889
FAX (714) 581-0969
Circle No. 708

LSI Logic Corp
1551 McCarthy Blvd
Milpitas, CA 95035
(408) 433-8000
FAX (408) 433-7715
Circle No. 709

Orbit Semiconductor
1230 Bordeaux Dr
Sunnyvale, CA 94089
(408) 744-1800
FAX (408) 747-1263
Circle No. 710

Panasonic Industrial Co
Two Panasonic Way
Secaucus, NJ 07094
(201) 348-7000
FAX (201) 348-7183
Circle No. 711

Plessey Semiconductor
1500 Green Hills Rd
Scotts Valley, CA 95066
(408) 438-2900
FAX (408) 438-5576
Circle No. 712

Quickturn Systems
325 E Middlefield Rd
Mountain View, CA 94043
(415) 967-3300
FAX (415) 967-3199
Circle No. 713

Sprague Semiconductor Group
115 Northeast Cutoff
Worcester, MA 01615
(508) 853-5000
FAX (508) 853-3353
Circle No. 714

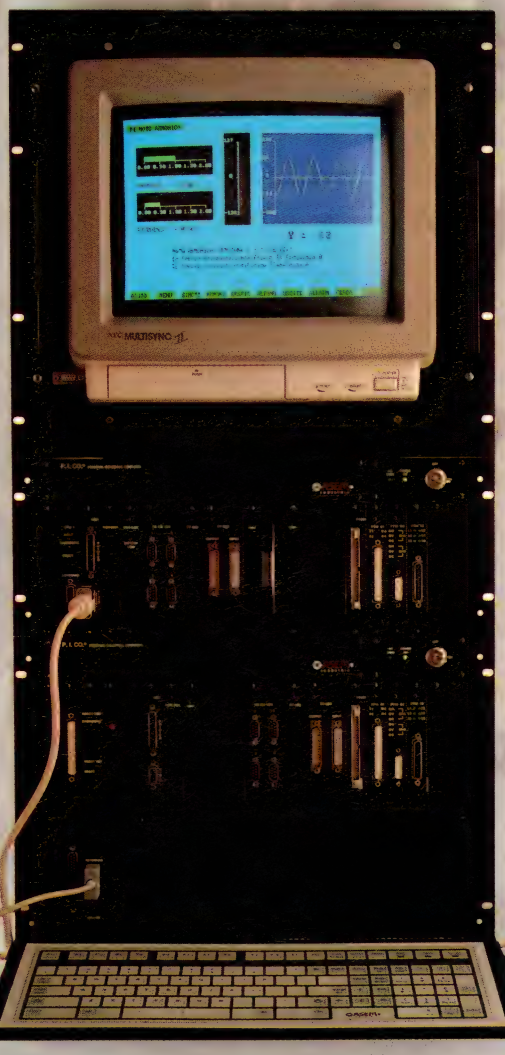
Texas Instruments
Box 655303 MS3686
Dallas, TX 75265
(214) 997-2190
Circle No. 715

Wyle Laboratories
18910 Teller Ave
Irvine, CA 92715
(714) 851-3935
Circle No. 716

Xilinx
2100 Logic Dr
San Jose, CA 95124
(408) 559-7778
FAX (408) 559-7714
Circle No. 717

P.I.CO: AN INDUSTRY TAILORED PC.

In order to consent the use of a PC architecture in the industrial field, ASEM INDUSTRIA S.p.A., with the pluriannual know-how of ASEM GROUP, makes it possible with a product based on the CMOS technology and using the EURO-CARD format, maintaining a complete Software and Hardware compatibility with all the PC available on the market.
A wide range of accessories as display, monitors and industrial keyboards allow different applications in harsh environments.
MS-DOS, UNIX, XENIX and QNX compatible.



ASEM INDUSTRIA

ASEM INDUSTRIA spa - Via Nazionale, 21
33010 Reana (UDINE) ITALY - Tel. 0432/880300
Fax 0432/880273 - Tlx 43504I ASEMIN I

CIRCLE NO. 40

The Layout Wow

Cadence Virtuoso™ Symbolic Lay



...out tools will wow you.

The first layout solution to support polygon and symbolic layout, symbolic compaction and layout synthesis. All fully integrated within Cadence Design Framework™ architecture. With one advanced layout editor to serve all three design styles. A solution engineered from the data base up to provide design flexibility that's never been available before. You can mix the best of polygon design, symbolic design, and layout synthesis — in one environment. Starting from polygon layout, you can migrate to symbolic layout and compaction. Cadence symbolic layout and compaction has been proven consistently in leading IC companies to provide 3x to over 5x productivity increase, and still provide area density comparable to manual polygon layout — Wow! And Cadence compaction technology provides the means to migrate designs to new process rules. Imagine migrating an entire library of cells from one rule set to another in a matter of days. And there's more. Automatic layout synthesis that generates symbolic cell layouts. Cadence Virtuoso Symbolic Layout tools. Proven productivity solutions that will reward you and wow you. For more information contact: Cadence Design Systems, Inc., 555 River Oaks Parkway, San Jose, CA 95134. Or call **1-800-283-4080, ext 866.**

CADENCE

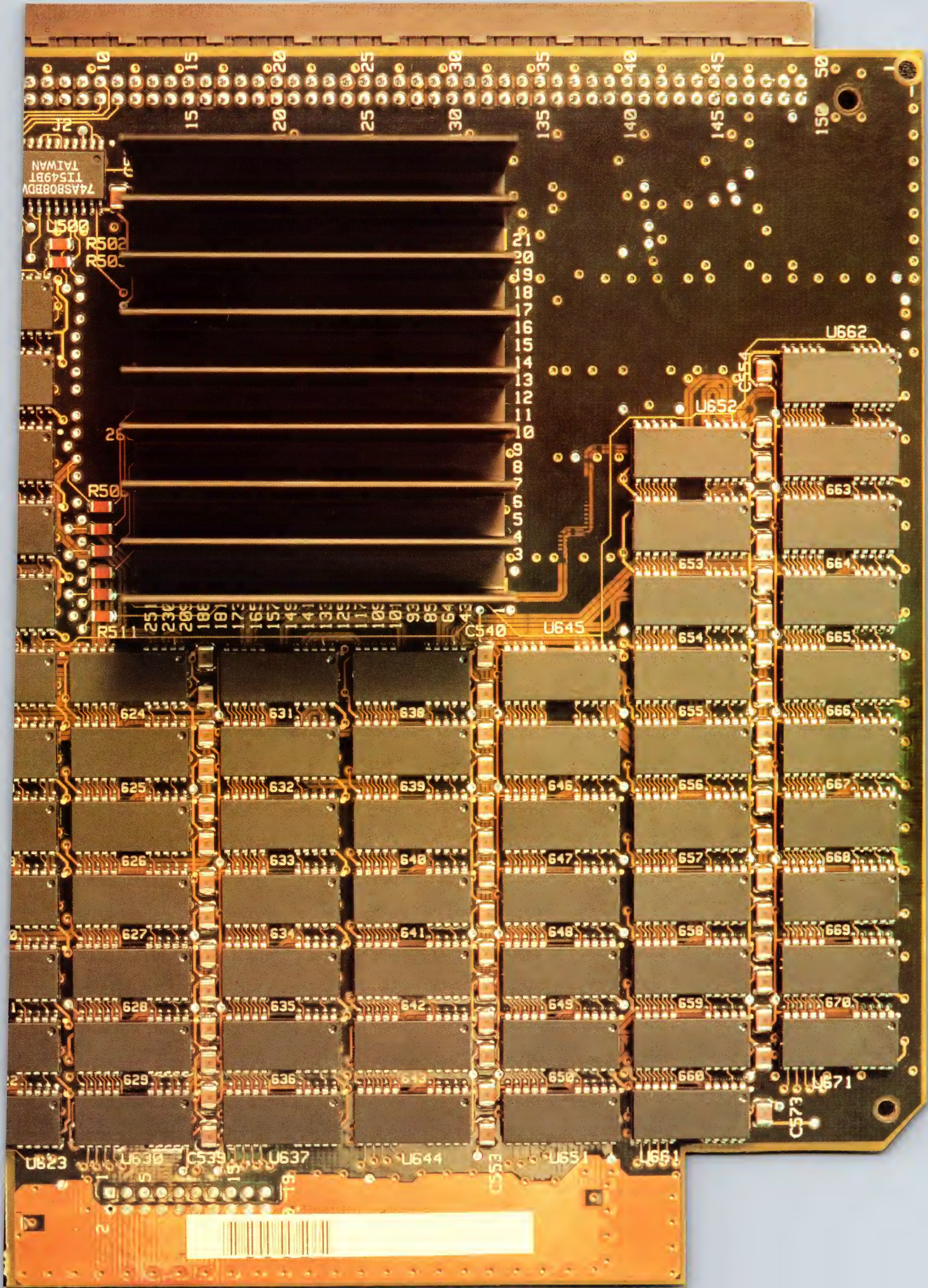
Leadership By Design

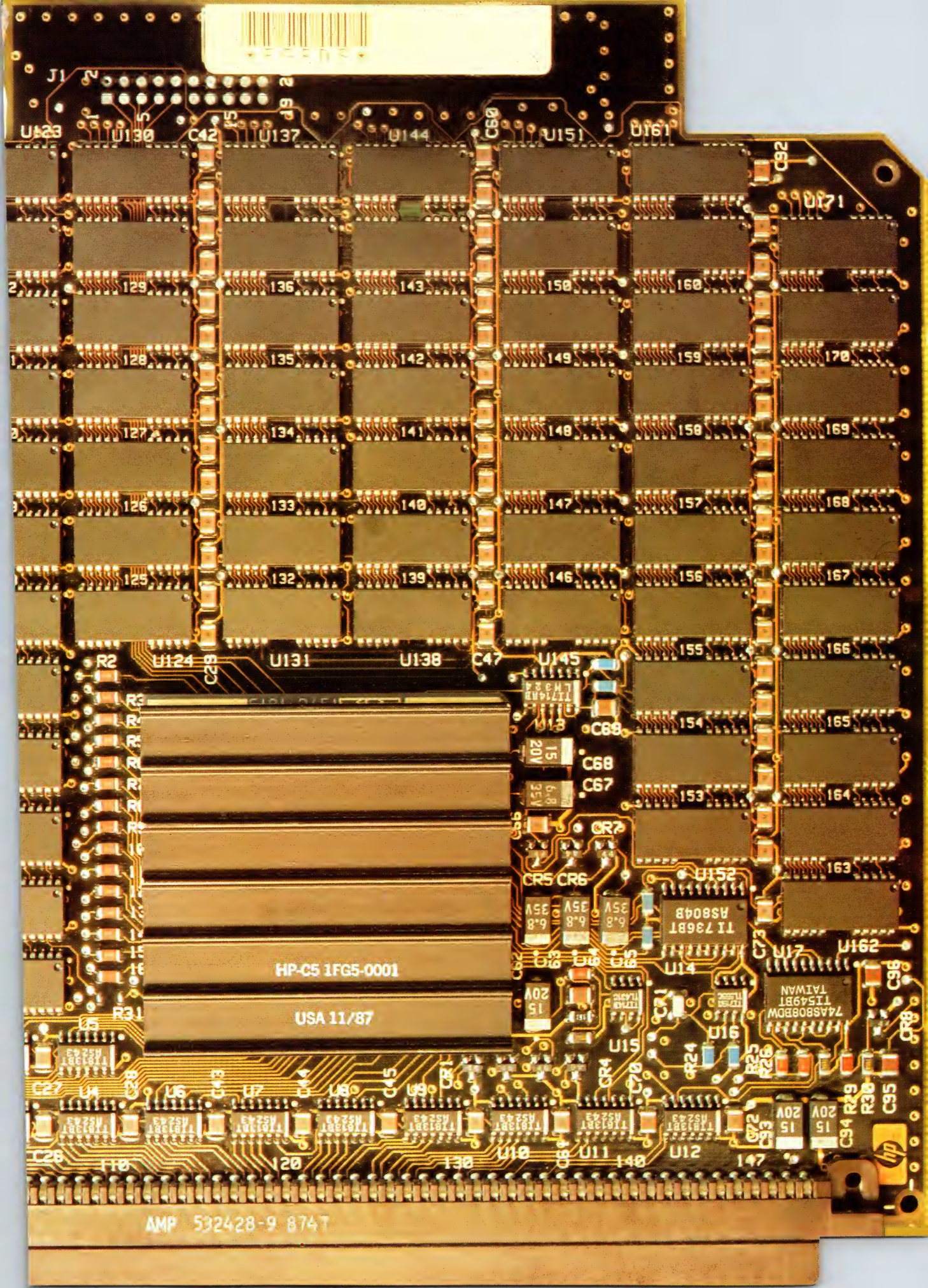
SEE US AT DAC BOOTH 3001

CIRCLE NO. 41

Virtuoso and Design Framework are trademarks of Cadence Design Systems, Inc.

To test this board with high accuracy, you need Hewlett-Packard on your side.


J2
74AS808BDV
TI549BT
TAIWAN
U500
R502
R501
R50
R511
C540
U645
U662
C554
U652
663
653
664
654
665
655
666
656
667
657
668
658
669
659
670
660
671
C673
624
631
638
625
632
639
646
626
633
640
647
627
634
641
648
628
635
642
649
629
636
650
U623
U630
C539
U637
U644
U651
U661


HP-C5 1FG5-0001
USA 11/87
AMP 532428-9 8747

Or better still, on both sides.

This is the ultimate test.

A complex SMT board, with fine pitch devices. Whether single or dual-sided, it's a real challenge for your tester (and your patience).

Yet with the help of Hewlett-Packard, you can make testing it simple.

Our latest HP 3065 and HP 3070 tester families are based on new fixturing technologies.

Quite simply they offer more accurate, more reliable probing than any conventional tester.

It means that fewer good boards fail, and there's less retesting.

So you're sure of higher productivity, with dramatic cost savings.

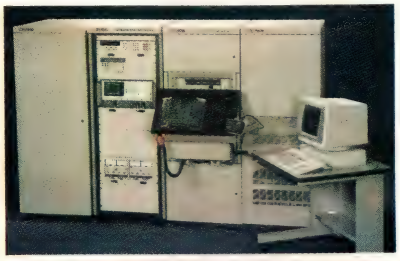
HP 3065 family for single-sided test
The HP 3065 incorporates a major advance in fixturing called HP Simplate technology.

For a start, we've developed a new, more compressible material to create a smaller vacuum chamber.

This allows shorter test probes, for higher probing accuracy.

And an advanced tooling pin design aligns the board more precisely, for better registration between the test probes and the board under test.

HP 3070 family with double-sided test
This is the state of the art in SMT testing.





To quote Electronic Times, it has "features that blow the competition away" and at "less than half the price of competing products, it is difficult to see how it can fail."

Again, the HP 3070 uses new fixturing techology – for single and dual-sided SMT boards, and automated SMT production lines.

A cassette fixture means that the board is positioned mechanically and held level by push rods. This eliminates board flexing and air flow across the board surface.

And redesigned electrical features such as short wires (on average 8cm, around a third the length of the competition) dramatically improve signal quality.

Add SMT part libraries, panelised board support, in-line automation, cluster testing...and you've a complete SMT board test solution for many years to come.

A complete upgrade path
HP's family approach makes it easy to upgrade and add more performance. Learn to use one machine in a family and you can use them all. So you minimise the cost and disruption of retraining.

Our testers also incorporate advanced software features to make programming and operation easy, (as you'd expect from a leader in computer technology). And they all include statistical process control and analysis software.

In short, whatever you need today, and however those needs may change, there's one certain path to success.

Put Hewlett-Packard on your side.

HEWLETT PACKARD

United Kingdom (0344) 369369 · Germany (06172) 4001634 · France (1-60) 774252 · Italy (02) 92103199

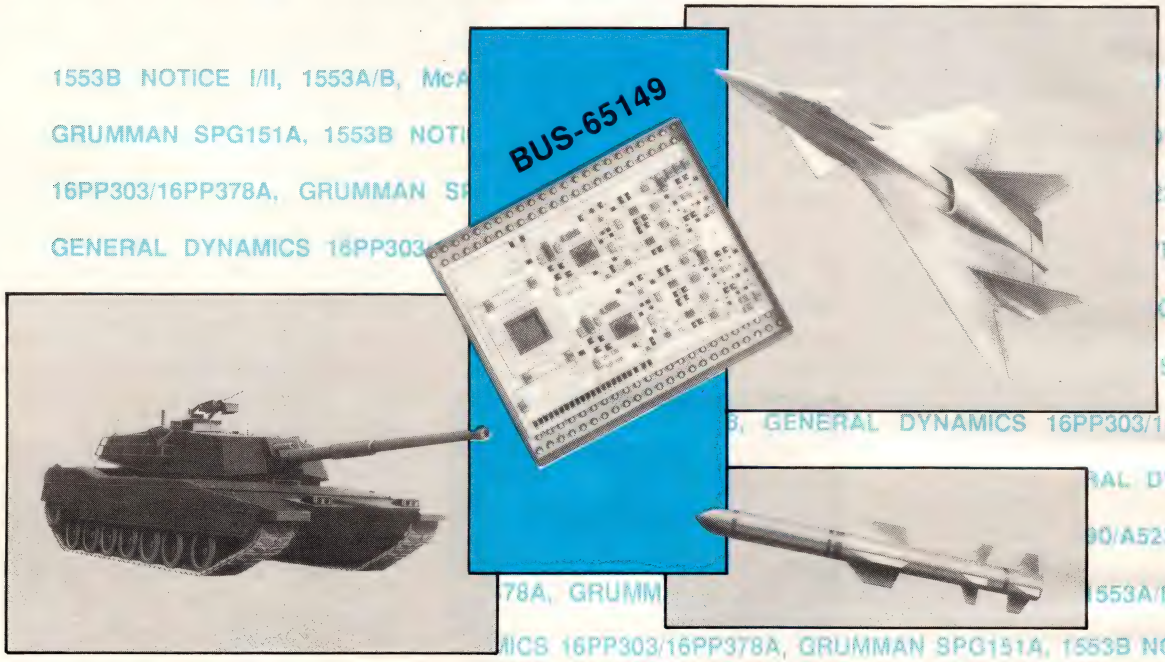
ADVERTISEMENT

NEWS

ABOUT
1553 DATA BUS
SYNCHRO CONVERSION
A/D & D/A CONVERSION
POWER & MEMORY HYBRIDS

DDC
ILC DATA DEVICE CORPORATION

UNIVERSAL MULTI-PLATFORM 1553 RT



The world's first stand-alone, dual redundant, universal MIL-STD-1553 Remote Terminal, DDC's BUS-65149, is now available. It provides the terminal designer with a self-contained 1553 RT design that operates in all present and earlier programs, as well as custom specified platforms. The universal transceivers and programmable protocol supports: MIL-STD-1553 "A" and "B"; NOTICE I & II; McAIR A3818, A5232, and A5690; the various GENERAL DYNAMIC (F16) 16PP303 and 378A protocols; and GRUMMAN SPG151A custom specifications.

Flexibility is provided through the programmable nature of the BUS-65149 RT terminal. The system can select "mode" (1553A/B, A enhanced, and broadcast enable), clock (12/16 MHz), and 8/16-bit shared RAM or DMA transfers. BUS-65149 provides the subsystem with an opportunity to enable any of the Status Word bits externally. In the 1553B mode, the appropriate bits are handled automatically. An internal BIT Word supports the 1553 Transmit BIT Word mode command transfer, while an optional external BIT Word can also be made available. The subsystem can read the BIT Word contents at any time.

The BUS-65149 universal RT is compatible with all microprocessors with its direct memory access (DMA) or shared RAM "mailbox" allocation scheme. In addition, the 8/16-bit DMA handshake and three-state parallel data and address buses facilitate the interface to simple systems without requiring the use of a microprocessor.

Illegalization of any command through the use of an external PROM, PAL, or RAM device is supported. All Mode Codes and message formats are implemented for the 1553 mode selected. Complete error detection capability is provided for: Sync, Encoding, Parity, Bit, word count, undefined commands, and RT-to-RT transfer errors.

The BUS-65149 is available fully screened to MIL-STD-883B in a MIL-STD-1772 certified facility and operates over the full military temperature range of –55°C to +125°C. **For additional product or applications information, contact Steve Friedman at 800-DDC-1772 (outside N.Y.) or call the DDC office nearest you.** □

DDC
ILC DATA DEVICE CORPORATION

HEADQUARTERS AND MAIN PLANT: ILC Data Device Corporation, 105 Wilbur Place, Bohemia, N.Y. 11716, (516) 567-5600, TLX-310-685-2203, FAX: (516) 567-7358
WEST COAST (CA.): WOODLAND HILLS, (818) 992-1772, FAX: (818) 887-1372;
SAN JOSE, (408) 236-3260, FAX: (408) 244-9767; GARDEN GROVE, (714) 895-9777, FAX: (714) 895-4988
WASHINGTON, D.C. AREA: (703) 450-7900, FAX: (703) 450-6610
NORTHERN NEW JERSEY: (201) 785-1734, FAX: (201) 785-4132
UNITED KINGDOM: 33 (635)-40158, FAX: 44 (635) 32264; **FRANCE:** 33 (1) 4333-5888, FAX: 33 (1) 4334-9762
WEST GERMANY: 49 (8191) 3105, FAX: 49 (8191) 47433; **SWEDEN:** 46 (8) 920635, FAX: 46 (8) 353181

Circle 121 for Sales Contact

Circle 122 for Literature

ELECTROSTATIC PLOTTERS

Fast plotters produce color and monochrome



The output quality and reliability of electrostatic plotters have improved, but most customers buy these raster units because of raw printing speed.

Maury Wright,
Regional Editor

Technology advances in color and monochrome electrostatic plotters have resulted in improvements in output quality and reliability. Unfortunately, manufacturers don't publish specs that readily quantify such improvements. However, the plotters do offer definable advantages compared with pen plotters in terms of plot speed—the units discussed here produce a typical color E-size plot in less than 10 minutes. Furthermore, prices of the raster units have dropped substantially—the D-size Raster Graphics Inc Colorstation D lists for $18,500. You can, however, spend $100,000 or more for a unit fully decked out for use in an IC-design application.

For designers, electrostatic plotters primarily fill the role of producing check plots in EDA (electronic design automation) applications. The plotters serve both pc-board and IC EDA applications. Typically, designers require color plots to identify the layers of boards or chips. A monochrome unit, however, will certainly save you money, provided that it fills your needs. Other technical, but nonelectronic, fields that use electrostatic plotters include geology, mapping, mechanical CAD, and architecture. **Table 1** lists a representative sample of electrostatic plotters.

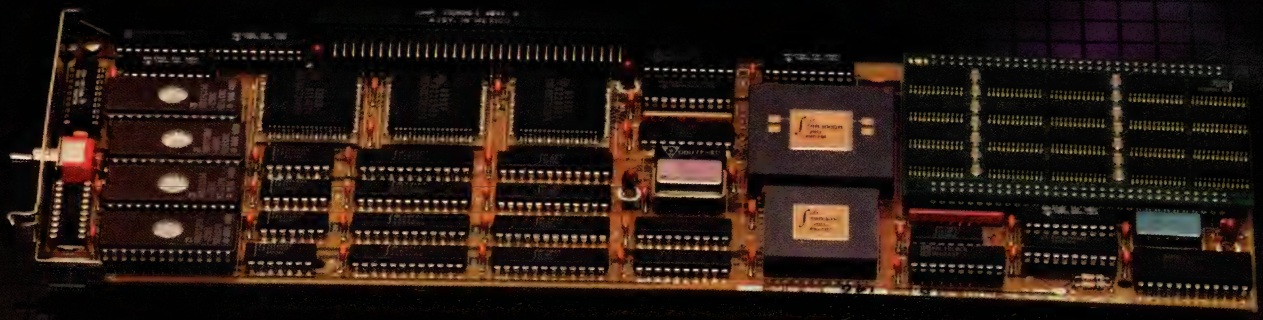
The plot quality of electrostatic plotters is noticeably better than it was only two years ago. You can now choose plotters that can print on a variety of media, including paper and film. The devices still don't print on plain paper, but the paper they do print on is acceptable in most applications. Toners, too, have improved. Electrostatic plotters can now produce vibrant full-color images in addition to serving as fast pen plotters.

Currently available electrostatic units

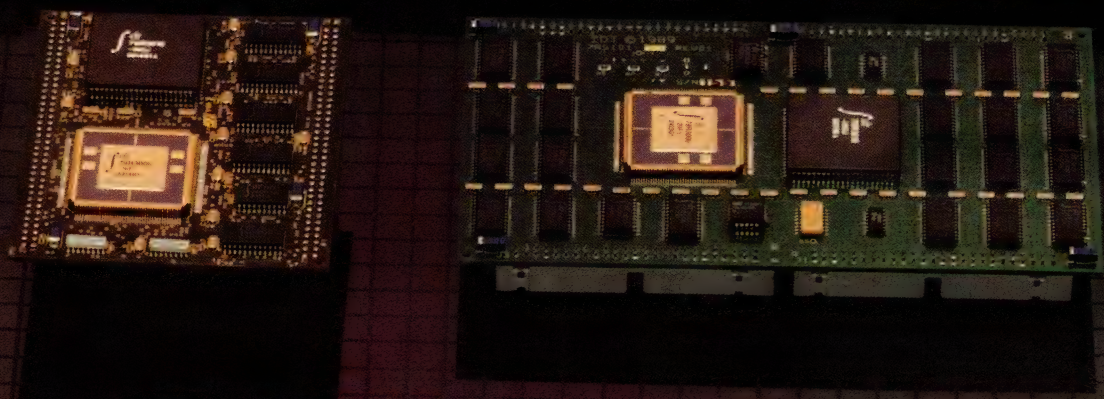


A 1-year warranty and $200/month service contract *on Hewlett-Packard's 6700 series plotters hints at a substantial increase in reliability compared with the history of electrostatic devices.*

Evaluate the Winning RISC. . . for $895

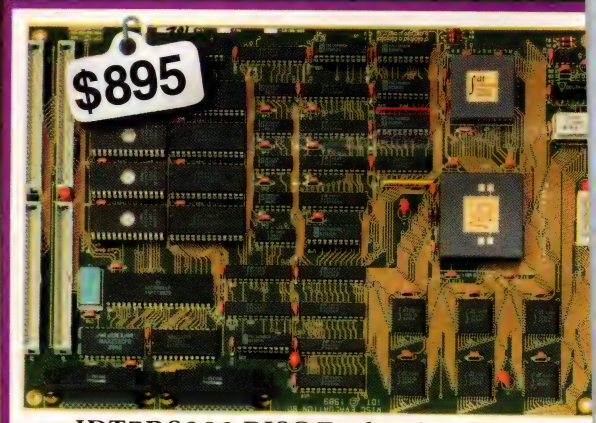


■ Development ■ Prototyping ■ Production



IDT mips R3000





IDT7RS382 RISC Evaluation Board

IDT has the broadest line of Mips™ R3000 RISC products available today, including microprocessors, modules, and development tools. You can count on us to provide the most cost-effective RISC solutions from evaluation through prototyping and into production. We developed the IDT7RS382 RISC Evaluation Board so you can easily evaluate the power of the winning RISC—and we're offering it for only $895! Call or FAX us today for complete specifications and ordering information. Or ask us for detailed information about any of the following product areas:

- ☐ **Evaluation Systems**
- ☐ **MacStation™ Development Systems**
- ☐ **Software Development Tools**
- ☐ **Module TargetSystems**
- ☐ **RISC SubSystem Modules**
- ☐ **R3000 RISC CPU and FPA Components**

Mips is a trademark of Mips Computer Systems.
MacStation is a trademark of Integrated Device Technology, Inc.

When cost-effective performance counts

Integrated Device Technology

(800) 345-7015
FAX: 408-492-8454

CIRCLE NO. 92

Electrostatic plotters

typically produce plots at a resolution of 400 dpi, and most can also produce 200-dpi plots. Versatec and Raster Graphics also offer 200-dpi-only versions of their plotters at reduced prices. In most installations, such plotters serve a network of users. And plotter manufacturers have started to offer network features in plotters.

To choose among the product offerings, you must weigh technical merits such as plot speed and output quality. You must also consider the logistic factors, including operator interface and ease of use. An understanding of how electrostatic plotters work will help you make buying decisions.

Electrostatic plotters operate by moving dielectric media past a writing head, through a wet-toner bath, and then through a drying process. The writing head consists of an in-line series of wire nibs that impart electrostatic charge to the media. The charge attracts toner particles. To be able to plot at 400 dpi, the writing head includes 400 wire nibs/in. across the width of the plotter (typically 24 to 44 in.).

Monochrome electrostatic units need only perform a single pass of the media past the writing head and through a toner bath. Color units must in essence perform four passes—one pass each for black, cyan, magenta, and yellow—to produce the full color spectrum. Manufacturers, however, have discovered a number of different ways to implement the color process.

Fig 1 depicts the most traditional color-electrostatic mechanism, and the one that most closely matches plotters from Calcomp Inc, Hewlett-Packard Co, and Versatec. Media, mounted in a reel-to-reel fash-

Table 1—Representative color and monochrome electrostatic plotters

Manufacturer/ Circle No.	Color plotters				Monochrome plotters				Color and monchrome features		
	Model numbers	Plot width	Plot length	Price range	Model numbers	Plot width	Plot length	Price range	Interfaces offered	Control languages	Other features
Calcomp Inc Box 3250 Anaheim, CA 92803 (714) 821-2000 **Circle No. 718**	58424 58436 58444	24 in. 36 in. 44 in.	28 ft	$49,000 to $77,500	57424 57436 57444	24 in. 36 in. 44 in.	Media length	$25,995 to $69,495	RS-232C, Centronics, *IBM channel, *4:1 serial multiplexer, *Ethernet	Calcomp 906 and 907, HPGL	12M-byte disk, *25M- to 280M-byte disk, *automatic media cutter, *automatic take-up reel
Hewlett-Packard Co 19310 Pruneridge Ave Cupertino, CA 95014 (800) 752-0900 **Circle No. 719**	7600, series model 255	36 in.	50 ft	$45,900	7600, series models 250 and 255	24 in. 36 in.	50 ft	$25,900 to $29,900	RS-232C, Centronics, IEEE-488	HPGL, HPGL/2, HP-PCL Level 5	1-year warranty, 40M-byte disk, automatic media cutter, automatic take-up reel
Precision Image Corp 501 Chesapeake Dr Redwood City, CA 94063 (415) 366-8900 FAX (415) 366-2149 **Circle No. 720**	C2536 C4836	25 in. 36 in.	D-size E-size	$49,200 to $59,200	M2536 M4836	25 in. 36 in.	D-size E-size	$32,900 to $38,900	RS-232C, Centronics, *IEEE-488, *Ethernet, *Dataproducts	HPGL, Calcomp 906 and 907, CGI, CGM	20M-byte disk, automatic plot stacker, drum technology, automatic panel generation for long plots, *85M-byte disk
Raster Graphics Inc 285 N Wolfe Rd Sunnyvale, CA 94086 (408) 738-7844 FAX (408) 749-0544 **Circle No. 721**	Colorstation D	22 in.	34 in.	$18,500					RS-232C, Centronics	HPGL, AT&T Targa	Steel-belt technology, automatic media cutter, one driver per head pin, automatic panel generation for long plots, *40M-byte disk
Synergy Computer Graphics Corp 260 Santa Ana Ct Sunnyvale, CA 94086 (408) 749-8600 FAX (408) 736-5880 **Circle No. 722**	Colorwriter 400	36 in.	Media length	$102,000 to $130,000					Centronics, Ethernet, *Versatec	HPGL, Calcomp 906 and 907, Versatec, Calma Stream	Single-pass technology, based on embedded Sun-3 workstation, media cutter, *two 155M- to 620M-byte disks
Versatec 2710 Walsh Ave Santa Clara, CA 95051 (408) 988-2800 FAX (408) 727-2399 **Circle No. 723**	8924 8936 8944	24 in. 36 in. 44 in.	10 ft with bailer, media length with reel	$32,000 to $69,400	8510 8524 8536 8624 8636	36 in. 24 in. 36 in. 24 in. 36 in.	9.1 ft D-size E-size media length media length	$13,900 to $27,900	RS-232C, Centronics, Versatec *IBM channel, *Ethernet	HPGL, Calcomp 906 and 907, Versatec	Automatic bailer (8900), *automatic media cutter, *60M- to 370M-byte disk, *automatic take-up reel, *200, 300, and 400 dpi

Notes: *=Optional; HPGL=Hewlett-Packard Graphics Language; HP-PCL=Hewlett-Packard Printer Control Language; CGI=Computer Graphics Interface; CGM=Computer Graphics Metafile

Electrostatic plotters

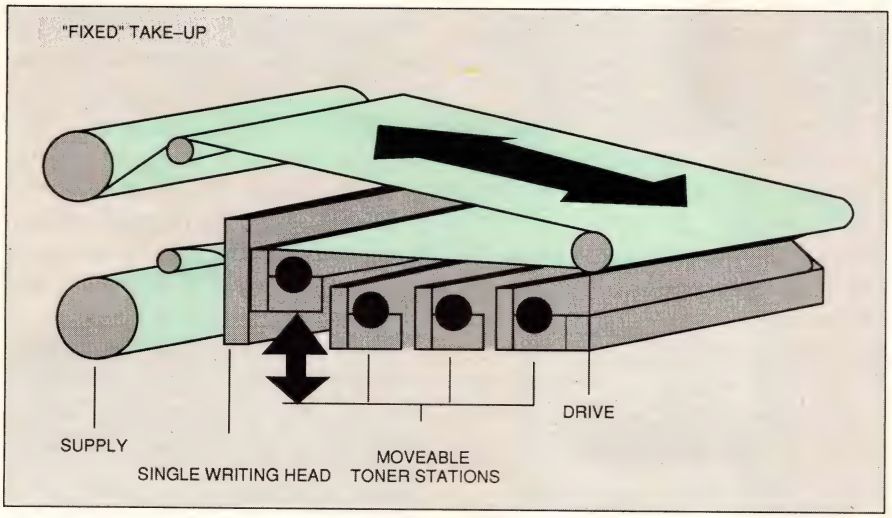


Fig 1—Four toner stations and a single writing head *allow electrostatic plotters to use reel-to-reel media movement and to produce full-color output.*

ion, moves forward through a plotting pass and is rewound for each subsequent pass. A single writing head charges the media on each of four passes. One of the four separate toner stations operates on each pass.

Single pass uses four heads

The single-pass mechanism (**Fig 2**) employs four writing heads and four toner stations in series. Such a plotter can place a full-color image on paper in one forward pass. In the past, Benson (San Jose, CA) offered a single-pass color electrostatic plotter, and today Synergy Computer Graphics Corp ships its Colorwriter 400 based on such technology.

Precision Image Corp and Raster Graphics have departed from the traditional design. They employ circulating media-transport mechanisms to move the media through the 4-stage plotting process. **Fig 3** depicts the Precision Image electrostatic plotters, which automatically load media from a tray of single sheets onto a cylindrical drum. A vacuum holds the media in place on the drum, and the media is skewed by 4° from the center axis of the drum.

The Precision Image plotters employ a helical-scan technique to perform the plotting process. A 2.56-in. writing head with 1024 nibs, also mounted at a 4° skew, writes a continuous helical spiral as the head moves horizontally across the width of the drum. A precision lead screw controls head movement, and, combined with the 4° skew, allows the small head to complete a full plot with 2.56-in. bands.

A roll of media supplies the Raster Graphics Colorstation D, but the plotter automatically cuts an engineering D-size piece of media before plotting begins. (Not all D-size plots are alike. Architectural D-size plots, for example, are a little bigger than engineering ones.) The device automatically loads the 22-in.-wide media onto a slightly wider stainless-steel belt. A vacuum holds the media in place. The belt circulates the media past a 22-in. 200-dpi writing head and four separate toner stations. The plotter passes the media through the plotting process twice for each of the four primary colors (eight passes total) to achieve 400-dpi plots. Between consecutive passes, the entire belt mechanism shifts horizontally by one half the distance between nibs.

All of the manufacturers designed the mechanics and printing processes of their plotters to achieve virtually the same goal—to produce high-quality output quickly, reliably, and at a low price. Manufacturers also strive to make the units simple to use.

All of the units discussed here produce plots of good quality. But again, specifications don't quantify the output in more definite terms. Plotter manufacturers list accuracy

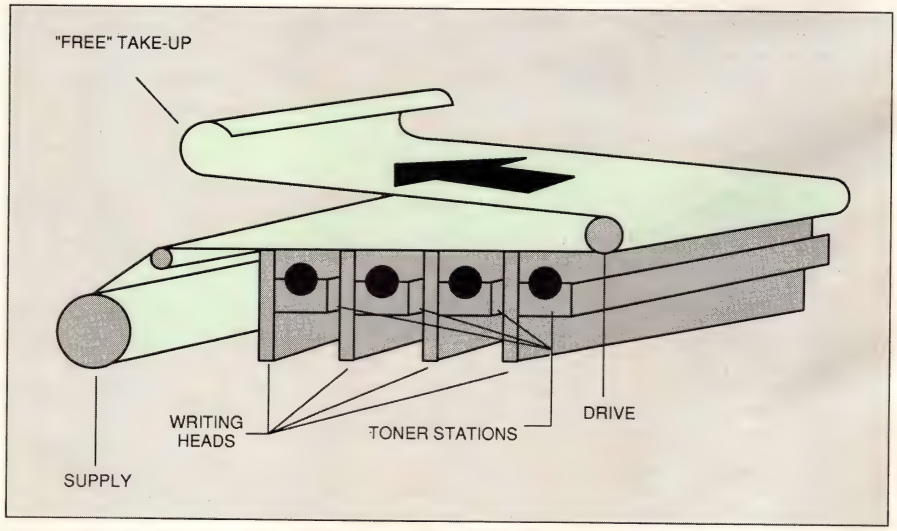


Fig 2—The single-pass electrostatic-plotter technology *embodied in Synergy's Colorwriter 400 employs four writing heads and four toner baths, and only moves the media in one direction.*



A few words of advice from high-performance µPLDs.

Chill out, PAL.

Many designers have hot, high-performance designs. Literally.

Fortunately, Intel has a simple way to reduce system heat and still get incredible performance. The µPLD Family of programmable logic devices.

Take, for example, the 85C220 and 85C224. They operate at 80MHz (100 MHz internally) with only a 10ns total propagation delay.

And since µPLDs are manufactured using Intel's CHMOS* technology, they require just 1/4 the power of their pin-compatible bipolar PAL* alternatives. Which means they can lower system heat by 35 percent and help reduce board-level failures, too. So they're certain to give your high-performance system a boost. And send chills up the spine of your motherboard.

Learn more about Intel µPLDs and receive a µPLD/PAL heat comparison. Call (800) 548-4725 and ask for Literature Packet #IA28.

Otherwise, you could take some heat over your system design.

intel®

© 1990 Intel Corporation. *CHMOS is a patented process of Intel Corporation. PAL is a trademark of AMD.

CIRCLE NO. 45

Electrostatic plotters

and registration specs that should indicate quality. No two manufacturers measure the specs the same way, however. Some list specs as a percentage of error, some as an absolute tolerance in inches, and some in terms of dot placement (for example, within one half of a dot). Before buying plotters, large aerospace companies develop test plots that allow them to measure characteristics of the individual plotters. Rather than concern yourself solely with specmanship, take a cue from the aerospace companies. Consider the apparent benefits of each manufacturer's design philosophy, and test each unit you consider.

Paper stretching is one potential event that lowers plot quality. Critics claim the traditional reel-to-reel approach used by Calcomp, Hewlett-Packard, and Versatec subjects the media to lengthwise stretching. Precision Image and Raster Graphics claim that their paper-transport mechanisms eliminate stretching. Likewise, Synergy claims its single-pass approach eliminates stretching.

Dennis Mudd, product manager at Hewlett-Packard, and Spencer Adamson, marketing manager at Calcomp, agree that the effect of humidity on the media is the main stumbling block for any of the plotters. Humidity constantly changes the media size during the plotting process.

All color electrostatic plotters lay down registration tracks, so the controller can compensate for media changes on subsequent passes. Even Synergy's single-pass device uses a registration track to monitor changes that occur between heads. In general, the plotters combine optical and/or mechanical sensors to sense location along a plot. The plotters also all sense horizontal paper alignment. A combination of motor-speed adjustments, fine-head movements, and adjustments in nib firing can compensate for media changes.

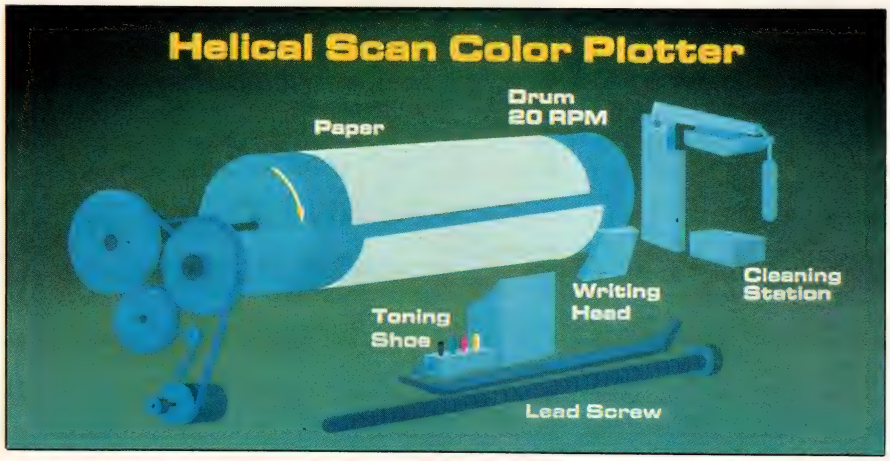


Fig 3—A helical-scan plotting scheme *based on drum technology allows Precision Image's plotters to eliminate the problem of stretching media.*

Precision Image and Raster Graphics do have potential advantages in that each plotter includes driver electronics for each nib in the writing head. The other manufacturers judge such a design too costly. They all use a limited number of drivers and multiplex them to fire all of the nibs. The multiplexing process creates potential energy and in some cases the energy exceeds the threshold of the media, resulting in stray dots called "flares."

The Precision Image units have small heads and therefore don't require many drivers. Raster Graphics only uses a 200-dpi head and therefore eliminates the need for half of the nibs and drivers in a 400-dpi plotter. The Raster Graphics unit also employs pc-board technology in its head. Other manufacturers use hand-wired heads. Manufacturing techniques for pc boards can't produce a 400-dpi head, but for 200-dpi applications they do produce heads that are more reliable and less expensive than hand-wired heads. The company also designed a custom nib-driver IC. Each IC drives 16 nibs; the chips are mounted directly on the combination pc board and writing head.

The individual designs the manufacturers offer probably affect logistical use of the machine more than quality, speed, and price. For example, some people may consider loading stacked D- or E-size paper in a Precision Image machine an advantage or disadvantage compared to the roll-feed method the rest of the manufacturers use. Likewise, the Precision Image and Raster Graphics plotters always output cut and stacked plots. But you can't produce plots longer than standard length without piecing panels of a plot together.

Traditionally, electrostatic plotters had a supply reel and a take-up reel. No one got a plot until the plotter was stopped and the take-up reel was removed. Such operation allows the plotters to produce plots of 25 ft or more, and to perform batches of plots in an unattended mode. Calcomp, Hewlett-Packard, and Versatec plotters all offer these traditional operations. Hewlett-Packard also includes an automatic media cutter and stacker as a standard feature in its plotters. You can buy an automatic cutter from Calcomp. The newest 8900 series of Versatec units can automatically roll individual plots and deposit them in a bailer. When operating



Best supporting cast.

An Award-Winning Line of Modem ICs and Support Chips

Silicon systems has added a large supporting cast of modem protocol and bus interface ICs to its award-winning line of modem products. This cast is made up of a variety of modem devices and chip sets which provide turnkey solutions for quick and easy modem system design. For integral modem applications, the cast includes bus interface and protocol controller products for MS-DOS and OS/2® compatibility in PCs, portable terminals, and other systems.

Modem device sets are available for AT protocol, MNP-5, CCITT V.42 and V.42 bis applications at speeds up to 2400 bit/s. These turnkey solutions can help you shorten your design cycle and allow you to add the latest standards, such as V.42 bis, with minimum software requirements.

In further support of its world-class K-Series modem devices and device sets, Silicon Systems has developed an exclusive family of compact 28-pin UARTs. These products have the lowest power and smallest footprint available and are provided in DIP or PLCC packages for both MS-DOS and OS/2 architectures.

If you want to reduce your design effort, shorten your design cycles, and have faster access to new industry standards like the CCITT V.42 error-control protocol – send for our literature package CPD-2.

Call your local representative or nearest Hall-Mark distributor, or contact:

Silicon Systems, Inc., U.S.A.
14351 Myford Road, Tustin, CA 92680.
Ph: (714) 731-7110, FAX: (714) 669-8814.
European Hdq. U.K. Ph: (44) 7983-2331.
U.K. FAX: (44) 7983-2117.

OS/2® is a registered trademark of Microsoft

silicon systems®

Circle no. 106 for Product Info
Circle no. 107 for Career Info

without a take-up reel, however, the plotters from these three manufacturers are typically limited to plot lengths around 10 ft.

Synergy's single-pass plotter can generate plots that are limited only by the length of media on the supply roll. You can also manually cut and remove a plot from the Synergy unit as it is plotted. The plotter moves paper in only one direction, so it does not require that a take-up reel be controlled. The plotter simply uses the natural curvature of the paper to produce a rolled output when left unattended.

The mechanical designs of the plotters discussed here also have little relevance to the plotters' true throughput. All of the manufacturers list plotting speeds that reflect the mechanical capabilities of the plotters. The specs do not account for multiple passes and rewind speed. Of greater importance, the plotting speeds on spec sheets don't reflect the horsepower on the controller in the plotter or the complexity of a plot.

Remember, a raster electrostatic plotter must accept an entire vector data file before it can begin plotting. Virtually all EDA applications work with vector data. The plotter controllers typically parse vector data as it is received and place it in an intermediate form on a buffer disk or in buffer memory. Once the controller receives the file, it performs a vector-to-raster conversion and prints on the fly during the conversion process.

You might think that Synergy's single-pass plotter would produce plots faster than the multiple-pass units from other manufacturers. However, rather than processing the data in individual layers, the



The paper bail holds rolled, finished plots *on Versatec's new 8900 series color electrostatic plotters. You can also buy an automatic take-up reel as an option.*

Thermal and laser units vie for monochrome market

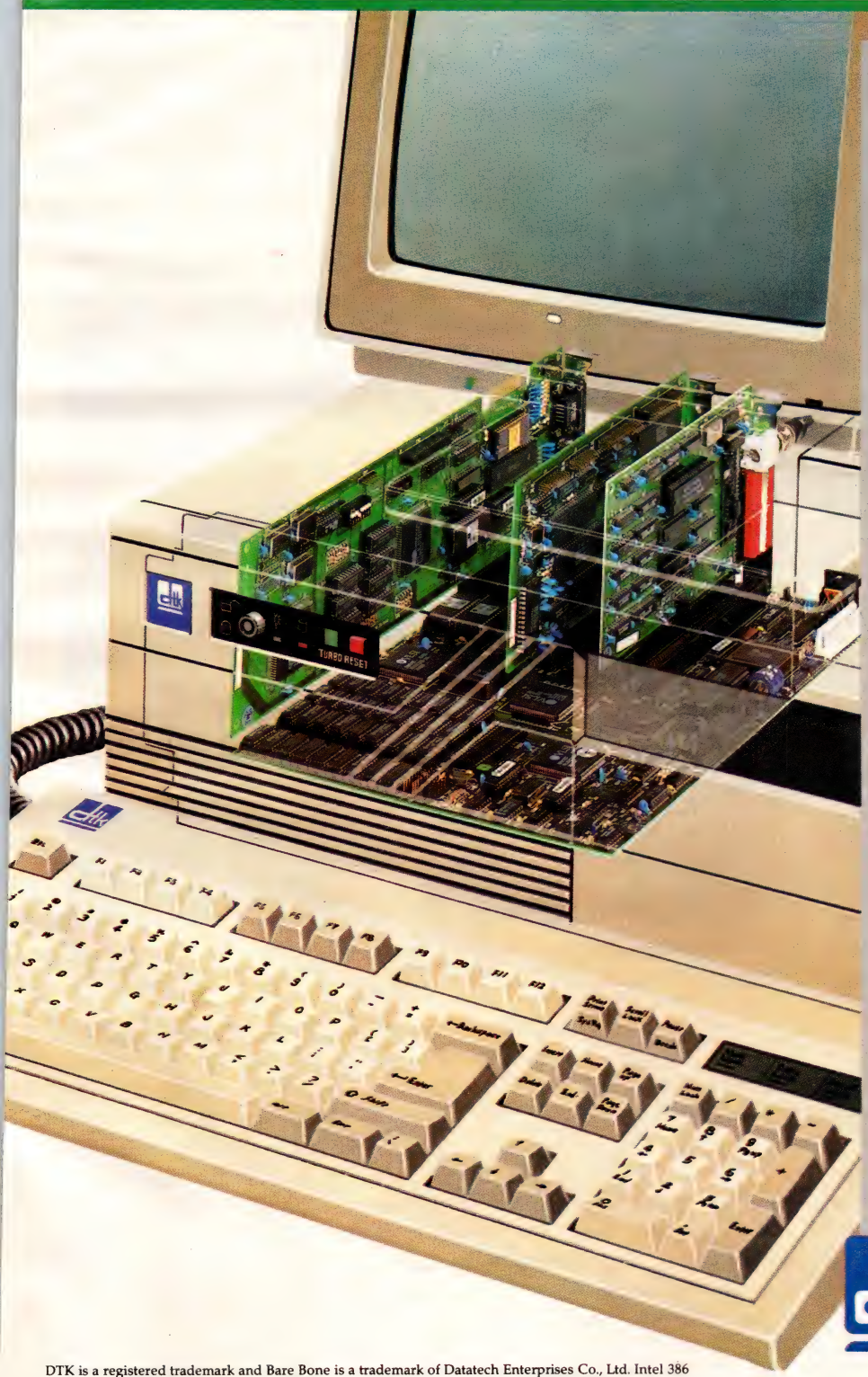
In cases where monochrome plots fill your needs, consider direct-thermal and large-format laser plotters as alternatives to electrostatic plotters. In general, thermal units cost less and offer lower resolution than electrostatic plotters, and they print faster. Laser plotters offer superb quality and fast output, but may prove a bit pricey yet for the mainstream.

Calcomp has led the way thus far in direct-thermal plotters. The D-size Model 52224 and E-size 52236 cost $14,995 and $19,995, respectively. The units can print two colors (red and black) and can produce plots that are as long as the media-input roll allows. The plotters include a 25M-byte disk drive and can plot on several media, including film. The quality of thermal paper doesn't match that of electrostatic paper, but it has improved significantly in the past few years. Calcomp has also been able to develop thermal paper that can be archived and will not discolor as older thermal paper does.

Plot speed for the Calcomp units varies from 0.5 to 1.8 ips, and the plotters offer 200-dpi max horizontal resolution and 400-dpi max resolution lengthwise on a plot. Roland Digital Group (Irvine, CA) offers a thermal plotter that makes B-size plots. The unit automatically accepts and scales C-, D-, or E-size plots. It costs $2995.

On the high end, Versatec offers its Model 8836 large-format laser plotter. The $39,000 unit prints on plain paper at 400 dpi, offers a constant plot speed of 1 ips, and can space 0.003-in. dots only 0.0025 in. apart. The plotter also cuts, rolls, and tapes each plot. You can specify the plotter with RS-232C, Centronics parallel, Versatec parallel, and LAN interfaces.

We've got the guts, you get the glory.



Your product shouldn't be a testing ground for inferior suppliers.

Today's sophisticated systems demand maximum compatibility and reliability. Your reputation depends on it.

DTK offers clearly superior 80386, 80286 and 8088-based Bare Bone™ systems with FCC, UL, CSA and TUV certification. Plus a wide line of motherboards that are fully compatible with AT™, XT™ and Micro Channel™ bus architectures.

They're all built to deliver the performance and reliability you need, even in rigorous manufacturing environments. We'll deliver them when you need them from our state-of-the-art 270,000 square foot manufacturing facility.

More Guts. Choose from a dozen Bare Bone systems designed to fit most of your needs. Or select from an extensive line of motherboards, including a 33MHz '386 with cache memory.

We can custom manufacture to your specifications, too. And we'll work hard to bring your projects in on time, and on budget.

Better Quality. Our substantial R & D capabilities and stringent QC procedures mean you can depend on us for the most reliable, highest performance products available today. And tomorrow.

Our inspection conforms with MIL-STD-105D, and our boards enjoy an overall reliability rate greater than 98%.

So why take chances? We've got all the guts you need at prices that are hard to beat. Go for the glory.

Call or write DTK COMPUTER, Inc., 15711 E. Valley Blvd., City of Industry, CA 91744.

Tel: (818) 333-7533
Fax: (818) 333-5429
Ask for OEM sales.

dtk®

Clearly superior.

DTK is a registered trademark and Bare Bone is a trademark of Datatech Enterprises Co., Ltd. Intel 386 is a trademark of Intel Corporation. AT, XT and Micro Channel are trademarks of IBM Corporation.

single-pass unit must simultaneously perform four vector-to-raster conversions. The single-pass technology also requires that the media move at a constant speed for an entire plot.

Controller paces plots

All of the plotters discussed here offer similar throughput. Typical E-size plot times range from six to 10 minutes. The time depends on the size of the vector data file and the complexity of the plot much more than the plotter mechanics or costs. Synergy does include an output disk in its units that queues printed processed plots. You can therefore make copies of E-size plots in just over a minute.

You may also find that connectivity and compatibility features influence your buying decision. Compatibility with HPGL (Hewlett-Packard Graphics Language) and Calcomp 906/907 ensures that a plotter is compatible with virtually all EDA-applications software. Hewlett-Packard also includes its PCL (printer-control language) level 5 in its plotters, making them compatible with its laser printers.

HPGL/2 will become important soon. The new language requires but one third of the vector data, compared to HPGL, to describe the same plot. A smaller vector data file significantly reduces the data-transfer time, and rasterization begins sooner. Only Hewlett-Packard offers HPGL/2, but expect others to follow. With the exception of Hewlett-Packard, all of the companies mentioned here plan to also offer Postscript for their plotters.

The plotters also typically include RS-232C and Centronics parallel ports as a hardware interface. You can buy several of the plotters with an Ethernet interface and TCP/IP (transmission control protocol/internet protocol) software built in. Synergy actually bases its unit on an embedded Sun-3 workstation that it buys from Sun Microsystems on an OEM basis. The Colorwriter 400 exists as a full fledged node on a network, and you can completely control plotter operation and its queue from any remote workstation on the network.

Calcomp, Precision Image, and Versatec all offer add-on LAN connections. The Precision Image unit simply includes an IBM PC/AT-compatible backplane to which you can add any type of network card you wish. Adding LAN capabilities to Calcomp or Versatec units costs $10,000 to $15,000 and results in capabilities similar to Synergy's product. You can also simply create a plot server for a LAN with a personal-computer clone, large disk drive, and LAN card.

Synergy's use of a full workstation base may seem excessive. The greater than $100,000 price also reflects the complexity that goes into every unit. Director of Marketing Robert Kosobucki claims that the Sun-3 base ensures customers of an upgrade path. For example, the company soon plans to replace the Sun-3 with a Sun-4. Existing customers will also be offered the upgrade, which Kosobucki claims will significantly increase throughput. Likewise, he claims that the design approach will allow the company to offer upgrades on the four rasterizers that each plotter requires.

Versatec has taken a different tact. It offers its customers a choice of plotter components virtually like component stereo for the home. You can buy a fully configured unit from Versatec. You can also buy a plotter with no rasterizer, and some software supports the company's raster-based plotter control language. Finally, you can buy a stand-alone rasterizer that can control more than one plotter. The company even offers the 300-dpi E-size monochrome CADmate unit for $13,900, setting a new price point,



The relatively diminutive size *and sub-$20,000 base price of the Raster Graphics Colorstation D make it suitable for use in small work groups.*

NEW GUTS
MULTIBUS I
NEW GLORY

These new Multibus I* products let you upgrade your existing applications with the latest silicon, the newest operating software, and expanded system capabilities. Easily. Quickly. Without costly redesigns. □ And, you can use these products to create powerful *new* applications on your favorite bus architecture. Without abandoning software and design tools. Or changing the way you work. □ Together with thousands of other Multibus I products, these latest offerings can add New Guts, New Glory, and years of productive life to more than 2 million installed Multibus I systems. And stimulate years of continued growth for one of the most popular open bus architectures in history. □ For complete information on any of these leading-edge products, just circle the appropriate reader service numbers. Or contact the manufacturers directly.

*IEEE 796 and Euroformat IEEE 796

386 CPU

The 20 MHz 386-based *CD21/8386* single board computer supports 1 to 16 Mbytes on-board DRAM, 2 iSBX connectors, DMA, 80387 or Weitek math coprocessor. (Compatible with Intel iSBC 386/3X.)

CENTRAL DATA
800·482·0315 FAX 217·359·6904
CIRCLE NO. 220

030 CPU

Heurikon's *HK68/M130* is a true 68030-based single board system. Key features include 4 or 16 Mbytes DRAM, SCSI, 4 serial ports, DMA, iSBX connector, and broad OS support.

HEURIKON CORPORATION
800·356·9602 FAX 608·831·4249
CIRCLE NO. 221

HIGH-INTEGRATION 386 CPU

Intel's *iSBC 386/12S* CPU board lets you upgrade Multibus I designs with 386 performance and integrated peripheral control. On-board SCSI frees a slot for added functions, and reduces system cost.

INTEL
800·548·4725
CIRCLE NO. 222

x86 CPU FAMILY

Micro Industries sources the complete National Semiconductor board-level computer line, as well as a complete family of Intel-compatible SBCs based on 8080 through 386 processors.

MICRO INDUSTRIES
614·895·0404 FAX 614·882·6357
CIRCLE NO. 223

32-BIT MULTIBUS-AMS

New *AMS M36* 386 CPU board for 32-bit *Multibus-AMS* (Euroformat IEEE 796) includes DIN connectors, 80387, 64Kb cache, 1Mb EPROM, 2Mb DRAM, 82380, 85C30, and Multibus II "OME" interface.

SIEMENS AG
Nuremberg, Germany
0049·911·895·3141 FAX 0049·911·895·3060
CIRCLE NO. 224

PC/AT COMPATIBILITY

Our *MAT286*™ SBC brings the whole world of PC DOS-compatible software to Multibus I, including EMS 4.0, enhanced color graphics, and solid state disks. Call for details.

SINGLE BOARD SOLUTIONS, INC.
408·253·0250 FAX 408·253·8298
CIRCLE NO. 225

MEMORY EXPANSION

Full line of memory modules to 16 Mbytes. Single- or Dual-Port (iLBX option), DRAM and non-volatile CMOS RAM, EPROM, E²PROM, or combination. One-year to lifetime warranty.

MICRO MEMORY, INC.
818·998·0070 FAX 818·998·4459
CIRCLE NO. 226

TOKEN RING CONTROLLER

The newest addition to SBE's line of SBCs and communications controllers is the *MLAN-T* Token Ring Controller, which provides interface to 4/16 Mbps Token Ring LANs.

SBE, INC.
800·347·2666 FAX 415·680·1427
CIRCLE NO. 227

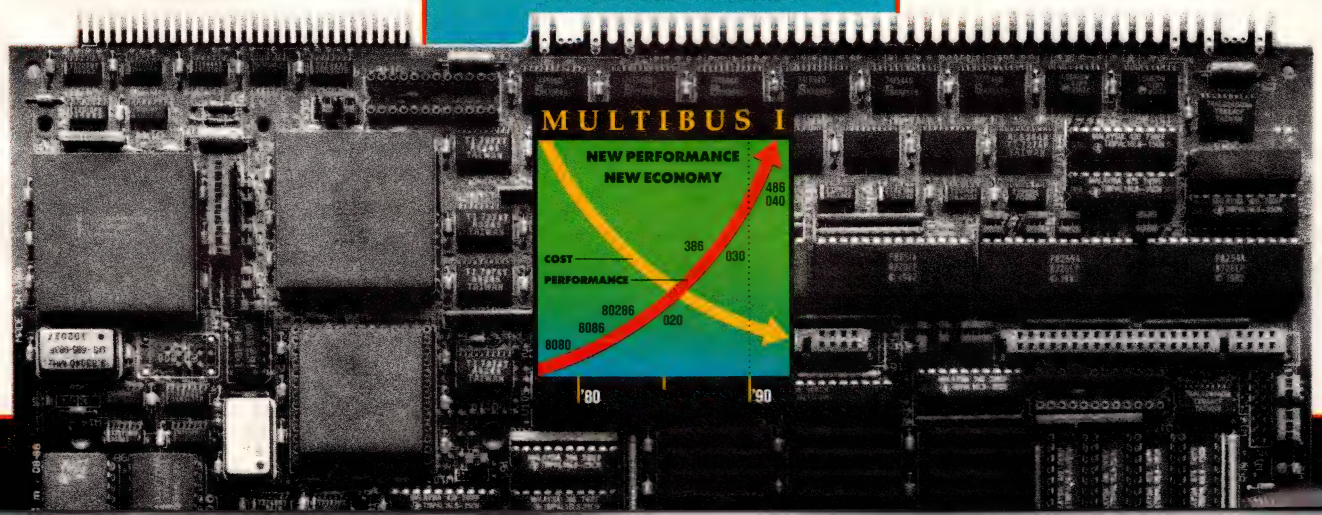
32-BIT REAL-TIME OS

iRMX®III Operating System is a 32-bit real-time OS for Intel386 and i486 microprocessors. Substantially increases performance. Full 16-bit binary compatibility simplifies application upgrades.

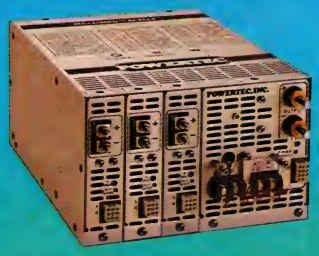
INTEL
800·548·4725
CIRCLE NO. 228

MULTIBUS MANUFACTURERS GROUP

P.O. BOX 6208, ALOHA, OR 97007
503·696·7155 FAX 503·696·2823
IN EUROPE: PHONE/FAX 0049·911·65 22 44



©Copyright 1990 Multibus Manufacturers Group

NEW! SWITCHMODE POWER SUPPLIES
FROM STOCK
■ 2 to 48 VDC Outputs
■ Automatic Current Sharing On All Outputs
■ N+1 Capabilities
MULTIPLE OUTPUT

■ 350 to 1500 Watts
■ 3 to 15 Outputs
SINGLE OUTPUT

■ 400 to 3000 Watts in 5″ × 8″ Standard Package
■ 155,000 Hrs. Demonstrated MTBF
Hot Plug-In
FAULT TOLERANT
(N+1) POWER SYSTEMS

■ Two to Six Supplies
■ Expandable, 300 to 1800 Watts
■ Internal Isolation Diodes (Option)
POWERTEC
A DIVISION OF ASTEC AMERICA, INC.
ASTEC
401 Jones Road, Oceanside, CA 92054-1216
Tel: (619) 439-4200 Fax: (619) 439-4243
CIRCLE NO. 47

TECHNOLOGY UPDATE

Electrostatic plotters

that depends on your personal computer to rasterize the data.

The final issue you should consider before choosing a plotter is reliability. Electrostatic plotters historically have been of suspect reliability. In fact, Hewlett-Packard recently made market news by introducing a product with a 1-yr warranty. All other manufacturers offer 90-day warranties. Mudd of Hewlett-Packard states the company's intent is to "bring reliability to electrostatic plotters."

All of the manufacturers claim to be building more reliable products today, but only Hewlett-Packard has backed the statement up. In general, expect to buy a service contract if you buy an electrostatic plotter. Hewlett-Packard stands out with its $200/month contract that covers anything that can go wrong with the product. Most other companies price the contracts at about 1% of the product's purchase price per month. In any case, you should determine exactly what a contract covers.

Today, you should be able to perform routine preventive maintenance, such as cleaning the heads and replacing toner, yourself. You may want to explore performing other maintenance in house as well. Precision Image encourages you to develop in-house expertise. The company regularly provides service training and will sell parts-only maintenance contracts.

Product targets work group

Raster Graphics may be pointed in the right direction to bring the plotters one step closer to plug-and-play status. Their device uses molded-plastic case parts, measures only 31×30×25 in., and weighs only 240 lbs. Contrast that with Synergy's product, which measures 46×63×44 in. and weighs 1400 lbs. The Raster Graphics device prints on 22-in.-wide engineering D-size documents, but does so for a base price of $18,500 ($22,000 with a 40M-byte disk and 400-dpi option).

Raster Graphics' Vice President of Marketing, Jack Androvich, sees a trend in the electronics industry of reducing the size of drawings used. Androvich believes that the use of CAE and CAD to produce perfect drawings eliminates the need for many big drawings. Raster Graphics' competitors, however, believe the E-size or bigger drawing is a must in the IC-design field.

There's no question that Raster Graphics has set a new price point for any size color electrostatic plotter. The price allows small work groups to have a plotter rather than sharing one with the rest of the company. They also have packaged the device in a way that enables most technocrats to uncrate it, set it up, and make it work—with no help. A continuing trend toward lower prices, easier use, and greater reliability will push the electrostatic plotter into applications as more than a pen-plotter replacement. The raster capabilities of electrostatic units, for example, can be used for thermal-analysis plots of ICs and pc boards.

Overall, electrostatic plotters still aren't simple like laser printers or even pen plotters. The devices include a substantial amount of plumbing, are relatively large and bulky, and require some expertise to install. That they have improved substantially is undeniable, however. EDN

Article Interest Quotient
(Circle One)
High 512 Medium 513 Low 514

You Spend Your Days In the Microcosm of Your Career...

Spend Your Nights In the Macrocosm of the Universe.

Meade 2045 Astrophoto: The Great Nebula in Orion.

Are you spending your days staring into the tiny screen of a computer? Maybe working with design rules in the submicron range? Possibly shielded from daylight? Certainly, shielded from the night sky. Don't you deserve better? Don't you deserve an intellectual and spiritual break from minutiae?

Let us suggest a wonderful way to expand your horizons. Consider the virtues of astronomy and a Meade Schmidt-Cassegrain telescope that can take you from your mundane world to the moon and beyond, out into our solar system and the stars. Not only to observe but to capture what you see in exciting high-resolution photos.

Meade Instruments now offers the ideal telescope for those with an awakening interest in astronomy as a hobby. It is the Meade Model 2045 Schmidt-Cassegrain instrument. Less than a foot long with a 4-inch aperture, this mirror-lens compound telescope provides the capability of a 4-inch refractor scope that is three times longer, heavier, and much more cumbersome.

Unlike a large refractor scope, the Model 2045's compact, portable design allows you to take it anywhere at a moment's notice, even as carry-on luggage on an aircraft. And although it is designed to pack neatly into a small carrying case,* no sacrifice has been made in its quality optical performance. Consider these features:

- Multi-coated optics that yield razor-sharp images of starpoints, planetary surfaces, deep-space objects, as well as terrestrial subjects.
- A table tripod that attaches quickly and easily to the drive base and is adjustable for observer's latitude.
- A strong rigid fork-mount for telephoto stability.
- Large setting circles for location of faint celestial objects from catalog coordinates.
- A 12-volt DC motor drive system for automatically tracking celestial objects—operating from an AA battery pack or with optional adaptors from an auto cigarette lighter plug, or from 120 VAC home outlets.

For more information on the Model 2045 and an exciting and educational new hobby that could change the way you and your family live the rest of your lives—send for literature and a special $25 rebate offer, or ask us for a product demonstration at your nearest Meade dealer. Use the phone, FAX or reader service numbers below.

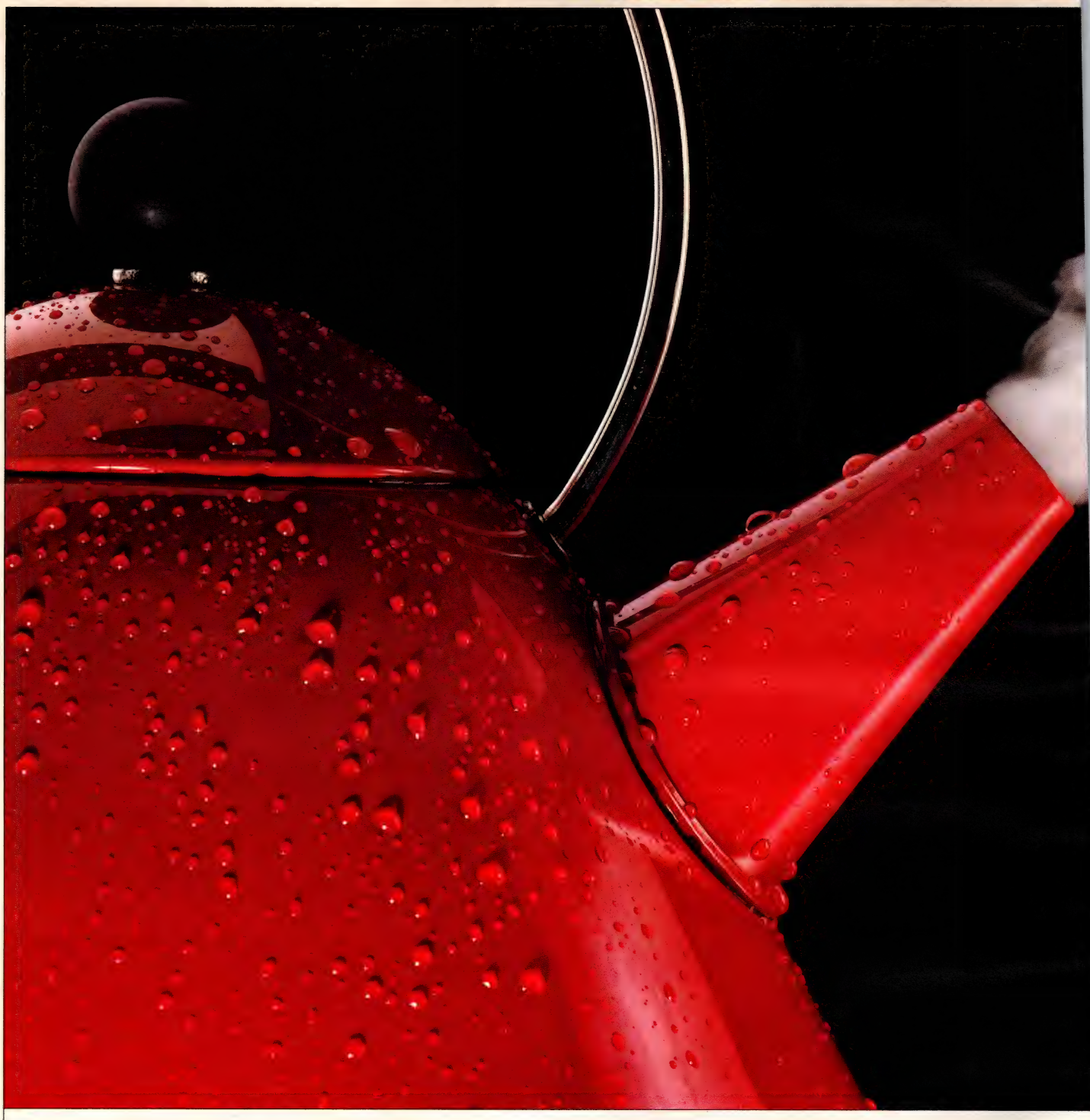
*Case optional



Meade Instruments Corporation
World's Leading Manufacturer of Astronomical Telescopes for the Serious Amateur

1675 Toronto Way, Costa Mesa, CA 92626
Phone: (714) 556-2291; FAX: (714) 556-4604
U.S.A. Outside California: (800) 854-7485

Literature: Circle No. 102 Dealer Demo: Circle No. 103



S-MOS MICROCOMPUTERS TAKE THE PRESSURE OFF YOU AND YOUR SYSTEM.

Extending the life of your battery can be a hot subject.

Fortunately, S-MOS has some cool news for those who need microcomputers that won't drain your battery. Our family of 4-bit microcomputers uses less power than anyone—with operating voltage as low as 0.9 V. With less current consumption you'll have more freedom to design in other functions.

Furthermore, S-MOS microcomputers have digital displays that signal a low battery. Two clocks let you optimize



your power consumption, which takes another load off your battery.

More features on-board

S-MOS microcomputers offer a wide range of on-board ROM and RAM, I/O ports and numbers, on-chip LCD drivers and other high performance peripherals. Plus, S-MOS' powerful PC-based development tools and add-on hardware help you develop SMC6200 Series applications quickly and cost-effectively.

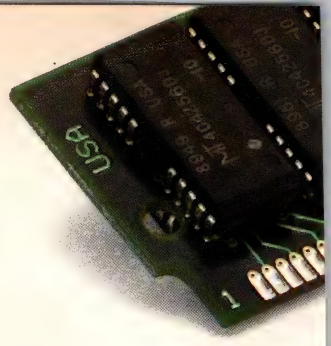
Part Number	Memory (bits)		LCD Drivers		Features
	ROM	RAM	Common	Segment	
SMC6214	4096	208 x 4	3 or 4	32	*AC, **BLD, Timer
SMC6215	x12	488 x 4		50	Twin Clock
***SMC6232	2048 x12	144 x 4	3 or 4	38	AC, Counter, BLD
SMC6246	6144 x12	640 x 4	8 or 16	40	Sound Generator Twin Clock, BLD
***SMC6281	1024 x12	96 x 4	3 or 4	26	Melody Generator, BLD AC
***SMC6235	4096 x12	574 x 4	3 or 4	48	Sound Generator Counter, BLD, AC
SMC6266	6144 x12	1024 x4	N/A	N/A	2 Channel AC Counter, Twin Clock

*Analog Comparator (AC) **Battery Level Detect (BLD)
*** Microcomputers running as low as 0.9V

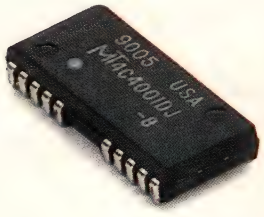
Take the pressure off now. For a **Free Mouse Pad** and our S-MOS Microcomputer Technical Guide, just call **1-800-888-1967 ext. 183.** And move full-steam ahead.

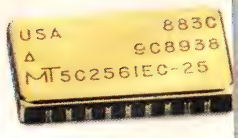
ASICs, Microcomputers, Memories & ChipSets

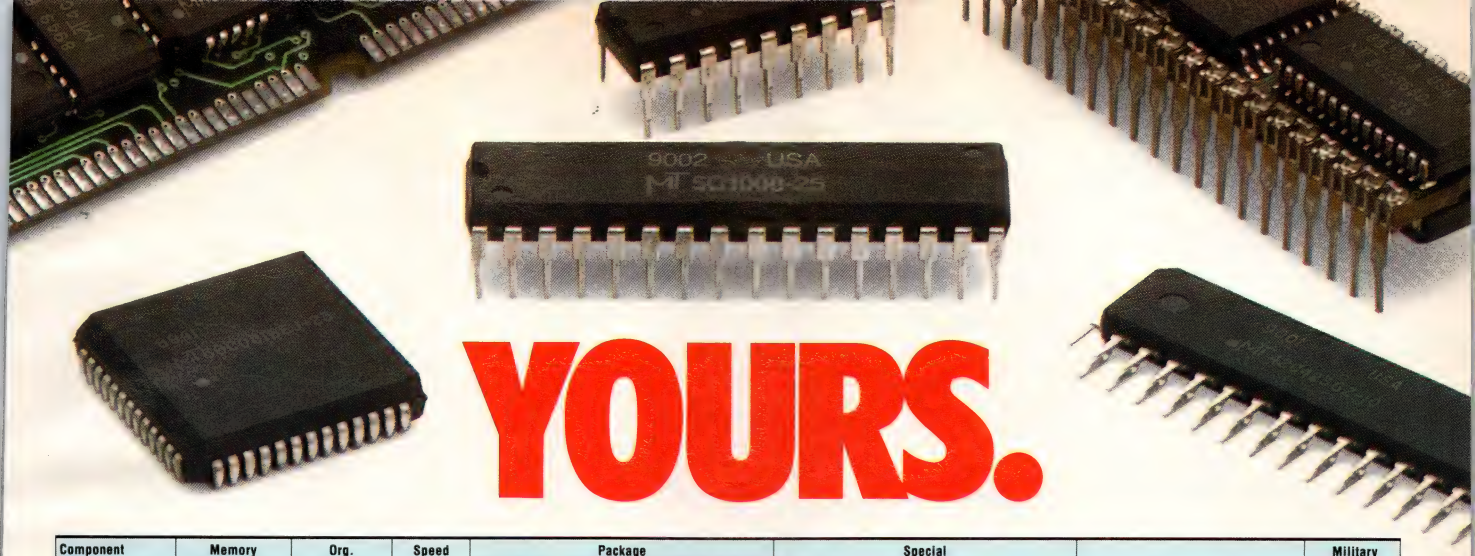
S-MOS
SYSTEMS
A Seiko Epson Affiliate



WE APPROACH THE MEMORY BUSINESS FROM ONE POINT OF VIEW...







YOURS.

Component Product Family	Memory Size (Total)	Org. (Bits)	Speed (ns)	Package						Special Features	Availability	Military Qualified
				DIP	ZIP	SOJ	PLCC	SOG	PQFP			
SRAMs	1MEG	x1,x4,x8	25-45	X		X				x4 option: OE	Samp: 1H90, Prod: 2H90	Samp: 2H90
	256K	x1,x4,x8	20-35	X	X	X				x4 option: OE	Now	X
	64K	x1,x4,x8	12-25	X		X				x4 options: Separate I/O, OE	Now	X
	16K	x1,x4,x8	12-25	X		X				x4 options: Separate I/O, OE	Now	X
Cache Data SRAMs	144K	x18	20-35				X		X	386/486 Compatible, Fast toe 8ns, Auto write completion, Parity bits	Samp: Now, Prod: 1H90	
	128K	x16	20-35				X		X	386 Compatible, Fast toe 8ns	Now	
SRAMs with Address Latch	16K	x8	100	X		X				Intel 8051 and 8096 compatible	Samp: Now, Prod: 1H90	X
	16K	x8	15-35	X		X				Compatible with high end micro controllers	Samp: Now, Prod: 1H90	X
FIFOs	18K	2Kx9	20-35	X			X			Family options: 300 mil DIP package, Programmable flags	Samp: 2H90	
	9K	1Kx9	20-35	X			X				Samp: 2H90	
	4.5K	512x9	20-35	X			X				Samp: 2H90	
DRAMs	4MEG	x1,x4,x16	60-100	X	X	X		X		x4 option: Write per bit	x1,x4 Samp: 1H90, Prod: 2H90; x16: 1991	
	1MEG	x1,x4,x16	70-120	X	X	X	X	X		x16 options: Byte and/or masked write	x1, x4: Now; x16: 1H90	X
	256K	x1,x4	80-120	X	X	X	X				Now	X
	64K	x1	100-150	X			X				Now	X
Quad CAS DRAM	1MEG	x4	70-100			X				Separate CAS control for each DQ input/output	Samp: 1H90, Prod: 2H90	
Pseudo Static DRAM	1MEG	x8	80-120	X		X		X		Unmultiplexed addresses, Simple refresh control	Samp: 1H90, Prod: 2H90	
VRAMs	1MEG	x4,x8	80-120	X	X	X				CMOS, Fully static SAM, Block write, Split read transfer	Samp: 1H90, Prod: 2H90	Samp: 2H90
	256K	x4	100-150	X	X	X				CMOS, Fully static SAM, Serial input	Now	X
Triple Port DRAMs	1MEG	x4,x8	80-120			X				CMOS, Two fully static SAMs, Transfer mask, Split transfers, Functionally compatible w/1MEG VRAM	Samp: 2H90	

Module Product Family*	Word Size (Words)	Org. (Bits)	Speed (ns)	Package						Special Features	Availability	Military Qualified
				DIP	ZIP	SIP	SIMM					
SRAM Modules	256K,64K,16K	x32	15-45		X					Industry standard pin-out with OE	16K, 64K: Now; 256K: 2H90	
	256K,64K,32K	x16	30-45	X						Industry standard pin-out with OE	32K, 64K: Now; 256K: 2H90	
	128K	x8	30-45	X						Compatible with 1MEG monolithic	Now	
DRAM Modules	2MEG,1MEG, 512K,256K	x36	70-120		X		X			Industry standard pin-out	256K, 512K: Now; 1MEG, 2MEG Samp: 2H90	
	4MEG,1MEG, 256K	x9	70-120			X	X			Industry standard pin-out	256K, 1MEG: Now; 4MEG Samp: 2H90	
	4MEG,1MEG, 256K	x8	70-120			X	X			Industry standard pin-out	256K, 1MEG: Now; 4MEG Samp: 2H90	
	256K	x5	100-120			X				Industry standard pin-out	Now	
	256K	x4	100-120			X				Industry standard pin-out	Now	

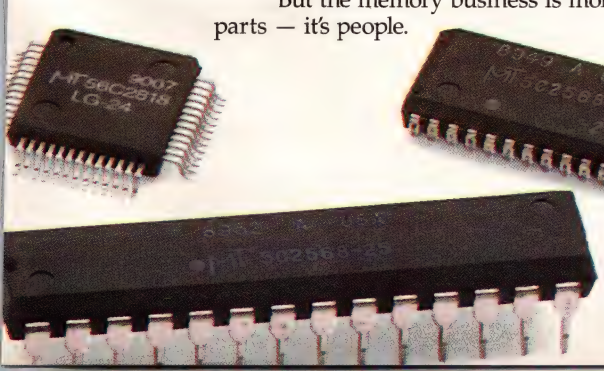
* Custom module and board-level product manufacturing services available.

At Micron Technology, we offer a full line of leading-edge RAM components in speeds and packages for virtually any application.

But the memory business is more than just parts — it's people.

That's why we offer a total commitment to service and support, and a team of engineers and technical support personnel that are the most experienced memory professionals in the industry.

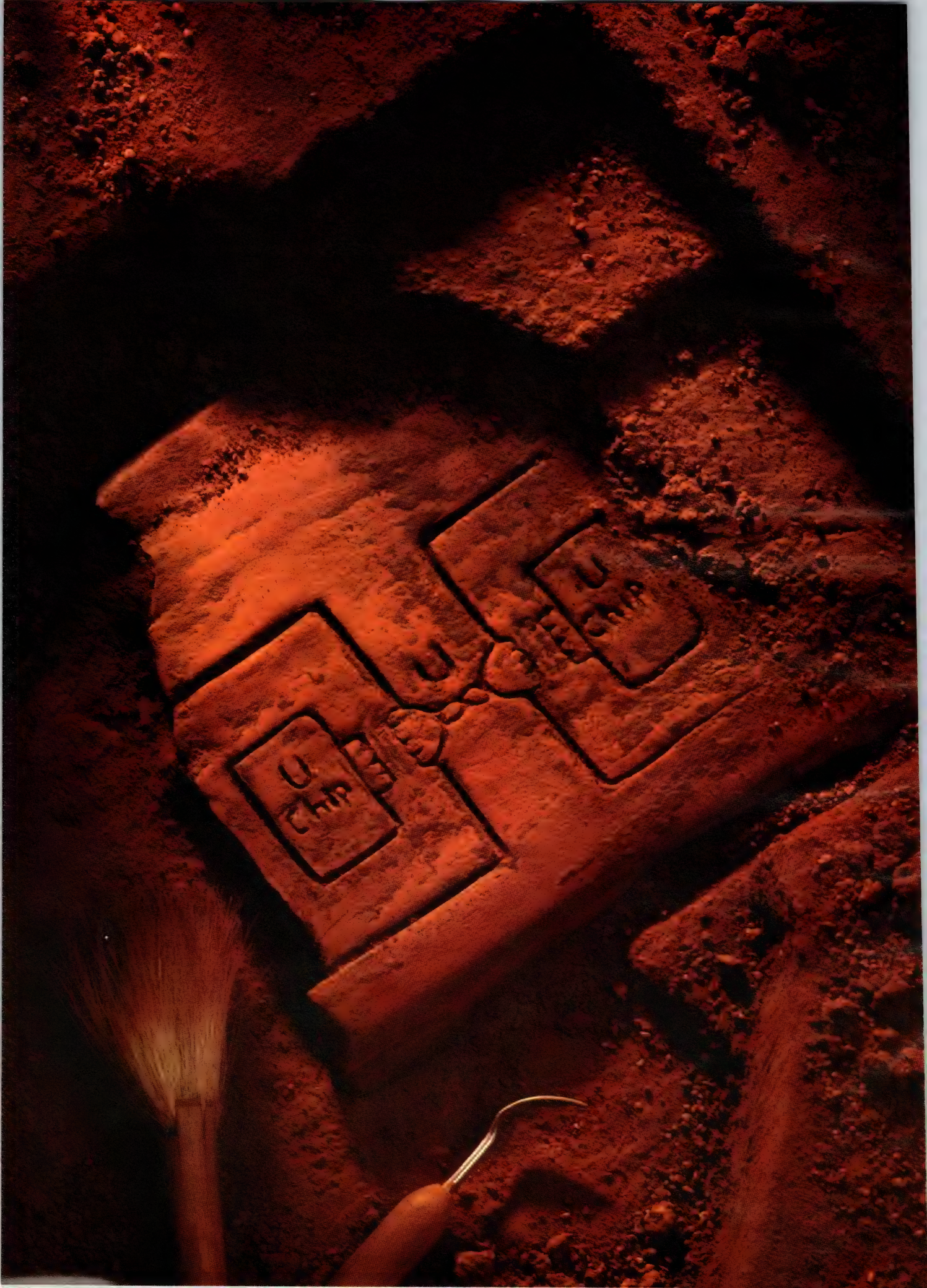
Because in the memory business there's only one point of view that counts. Yours.



MICRON TECHNOLOGY, INC.

2805 E. Columbia Rd., Boise, ID 83706 (208) 386-3900

CIRCLE NO. 49


JUST
ADD
WATER

The missing link in ISDN.

Discover complete U transmission in a single chip.

Unearth the secret to ISDN Basic Access with Motorola's advanced 2B1Q U-interface solution. The single-chip MC145472 U-interface Transceiver fully conforms to ANSI T1.601-1988, the North American standard for ISDN Basic Access on a single twisted-wire pair. The MC145472 U-Chip provides a complete U-interface solution for digital subscriber line cards, network termination equipment, and customer premise equipment.

Discover Motorola's U-Chip and move ahead with the development of standardized ISDN Basic Access equipment in North America and beyond.

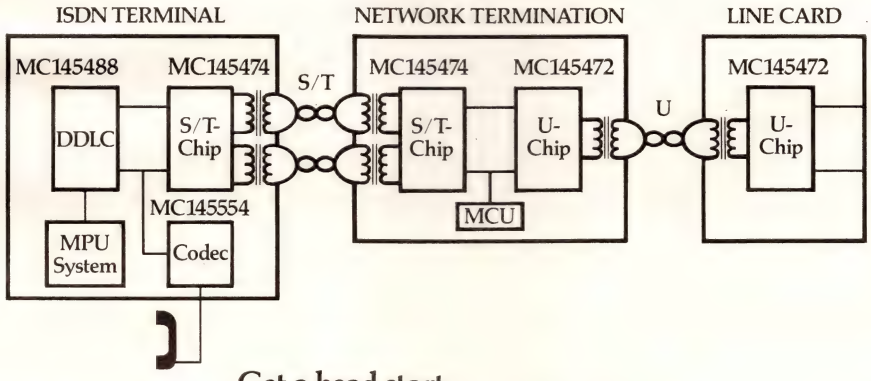
It's the one-chip answer.

Motorola's MC145472 U-interface Transceiver provides 160 kbps full duplex communication over a single twisted-wire pair. And it achieves 10^{-7} bit error rate performance on all ANSI specified test loops with worse case impairments present. This impressive performance results from combining precision analog signal processing elements with three digital signal co-processors to build an adaptively equalized echo cancelling receiver. All on one 1.2 micron technology CMOS chip.

Versatile maintenance.

The Motorola U-Chip provides your choice of two modes for handling the U-interface maintenance channel functions. In the automatic maintenance mode, the U-Chip handles all ANSI specified maintenance channel procedures internally to minimize your software development effort. The automatic procedures include generating and monitoring the cyclic redundancy check, reporting and counting far end block errors (near end block errors, too), handling the "act" and "dea" bits, as well as monitoring and appropriately responding to embedded operations channel messages.

The optional manual maintenance mode lets you choose an inexpensive micro-controller, such as a member of Motorola's MC6805 family, to control and augment the system maintenance channel functions. This flexible feature also allows for easy implementation of proprietary maintenance functions.



Get a head start.

Motorola offers a complete U-Chip design-in kit to help you get started. The MC145494EVK kit has all the hardware, software (including source), and technical information you need to explore custom U-Chip applications. The kit includes a fully operational line termination (LT) and Network Termination (NT1) ready to operate stand-alone for developing an NT1. The U-Chip and S/T-Chip are both on-board and already communicating.

Developing U-interface and/or S/T-interface terminate equipment? The MC145494EVK connects directly to Motorola's MC68302 Integrated Multiprotocol Processor Development System, providing either ISDN physical interface to the MC68302 for a complete terminal solution. And it's all supported by trained applications engineers in the field and at the factory.

For more information.

The U-Chip is just the latest addition to Motorola's ISDN Family. For more information on any of our ISDN devices, simply contact your local Motorola sales office or complete and return the coupon below.

MOTOROLA



Write To: Motorola Ltd., European Literature Centre, 88 Tanners Drive
Blakelands, Milton Keynes MK14-5BP, United Kingdom

Please send me more information on the U-interface Transceiver and Motorola's other ISDN products.

433EDN062190

Name _____

Title _____

Company _____

Address _____

City _____

Country _____



Military DC/DC Converters
Single, dual and triple output

DC/DC converters from Advanced Analog have the power and reliability needed for military and aerospace systems.

- -55°C to +125°C and -55°C to +85°C temperature range
- True military screening in a MIL-STD-1772 certified facility
- 15 watts to 80 watts output power
- Hermetically sealed
- Advanced feedback method uses no optocouplers for high reliability and greater radiation tolerance
- Compatible EMI filter

Now you can get a complete range of DC/DC converters with the higher temperature range your system requires. And improved performance. Advanced Analog's converters are built for rugged environments and guaranteed to outperform any other standard DC/DC converter of this type.

Small — as small as 1.1″ x 2.1″ x .495″ in a standard or rugged flange mount hermetically sealed package.

Special converters or power hybrids can be manufactured to exacting standards including Class S. Call us and we'll work with your team to get the best solution for your needs.



DC/DC Converter

AHE Series	15/20 watts	single/dual
ATW Series	30 watts	single/dual
ATO Series	15 watts	triple
PS Series	27/80 watts	triple

-55°C to +85°C and -55°C to +125°C
Input voltage range is 14.5 - 40V

MIL-STD-1772
Certified Facility

Advanced Analog
a division of Intech

2270 Martin Avenue
Santa Clara, CA 95050
(408) 988-4930

CIRCLE NO. 51

SMART-POWER ICs

Off-the-shelf circuits increase in popularity



An increasing number and variety of smart-power ICs are now available as standard products.

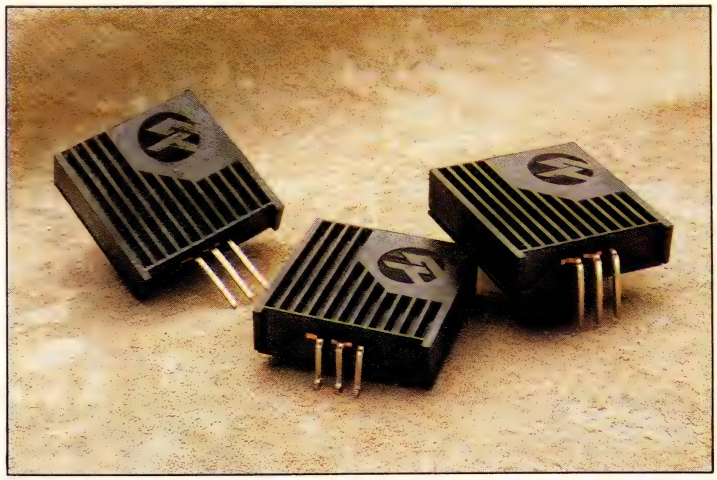
Dave Pryce,
Associate Editor

Smart-power ICs will never completely replace the various combinations of logic, linear functions, and power that monolithic ICs and discrete power devices provide, but they are making inroads. Once largely hidden in custom circuits, many smart-power ICs are now available as standard products that can satisfy an ever increasing range of applications. When off-the-shelf devices are not exactly what the doctor ordered, some companies offer semicustom circuits that will help get you over the cost-quantity barrier of a custom device.

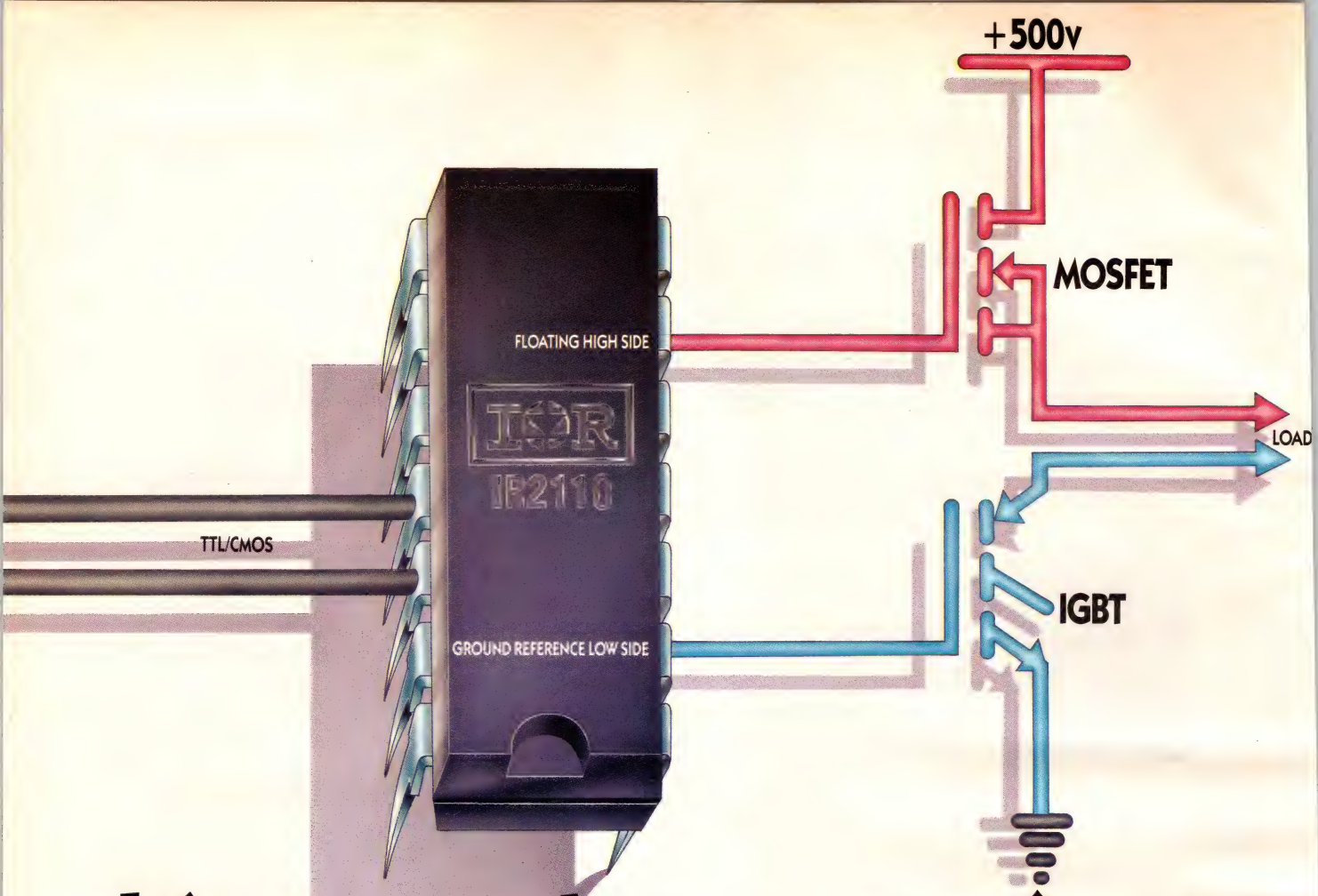
The term "smart power" is difficult to define. Because of its catchy name, vendors have applied the term to products that only marginally qualify as smart-power devices. Some definitions specify an output voltage rating of 50V or greater without regard to the device's current rating. Any reasonable definition of smart-power specifies a power-handling capability of at least 1W. So a 50V device with a current rating of 10 mA, for example, wouldn't qualify in terms of its power rating.

Far more difficult to define than a minimum power rating is the amount of intelligence or "smarts" a device needs to qualify as being smart. Just as beauty is often in the eye of the beholder, so too can the intelligence of a smart-power device be in the mind of the vendor. Common sense, however, dictates that the device must have a significant amount of intelligence. The intelligence can be in the form of control functions, interface capability, or fault management. It is the imprecise word "significant" that defies definition.

Despite the lack of a commonly accepted definition, smart-power ICs represent a technology that is applicable to many of today's system requirements. These intelligent circuits ease the interfacing of digital and analog ICs with discrete power devices. With most of the required circuitry contained in a single package, both monolithic and hybrid smart-power ICs offer system designers the benefits of reduced size, greater reliability, and increased protection. This last benefit is often where a



These integrated switching regulators *from Power Trends Inc are drop-in replacements for the 78 series of TO-3 and TO-220 linear regulators. Initially available in 1.5A versions, these hybrid ICs integrate a control circuit, a FET, a Schottky diode, and an inductor. The devices operate at 1 MHz and have power densities of 40 to 200W/in³.*



It's never been easier to get a gate off the ground.

Now you can replace a fistful of components, and drive power FETs and IGBTs with one cost-effective part: The IR2110 monolithic dual channel 2A gate driver with floating high side and ground reference low side.

Count your design time in hours instead of days. And cut assembly time to a fraction.

The IR2110 runs as fast as it designs. With operation above 1 MHz. On-chip bootstrap. Plus matched channel delay within 10 ns. That's right. 10 ns.

It takes good care of your circuit too, with gate under-voltage protection.

And latched shutdown makes current mode control both simple and easy.

IR2110



Is it rugged? 50 V/ns dv/dt at –55 to 150°C in plastic. Versatile? Operates off 12 to 500 V rails with 5 to 20 V input, in any circuit topology. Reliable? The IR2110 meets the same high standards as IR's incomparable HEXFET® power MOSFETs.

Call (800) 245-5549 for more information. We'll get it off the ground and on your desk in no time.

International Rectifier

WORLD HEADQUARTERS: 233 KANSAS ST., EL SEGUNDO, CA 90245, U.S.A. (213) 772-2000. TWX 910 348-6291, TELEX 472-0403. EUROPEAN HEADQUARTERS: HURST GREEN, OXTED. SURREY RH8 9BB, ENGLAND TELEPHONE (0883) 713215, TELEX 95219

CIRCLE NO. 52

Smart-power ICs

smart-power device really demonstrates superior intelligence—that of protecting itself against potential catastrophes such as voltage overloads, short circuits, and thermal runaway.

Examples of these self-protecting devices include the LM1951 from National Semiconductor, the LT1188 from Linear Technology, the SP306 from Harris, the HA13702A and HA13703A from Hitachi, and the BTS-412A and the BTS-432 from Siemens. Current ratings for these devices range from 1 to 12A; unit prices range from $2 to $6 (1000). These devices typically feature protection against short circuits and thermal overload as well as against reverse-voltage, overvoltage and undervoltage conditions. Most also include a status pin for diagnostic purposes. Deceivingly simple in appearance, these 5-lead TO-220 devices are really quite smart. Moreover, all are high-side drivers that meet the ground-return needs of many automotive applications (see **box**, "Low-side versus high-side switching").

Although some manufacturers successfully implement many of their smart-power ICs using plain-vanilla bipolar processing, most have turned to more complex processing technologies to obtain the performance levels demanded by many applications. For example, the pin-compatible IR2110 from International Rectifier and SP606 from Harris Semiconductor combine low-voltage bipolar and CMOS devices with high-voltage DMOS output devices.

Essentially identical, the 500V IR2110 (**Fig 1**) and 600V SP606 are half-bridge drivers for use in power-conversion and motor-control applications. The devices operate at frequencies as great as 1 MHz and have a peak-current rating of 2A. Their output stages have independent high-side and low-side output channels. Each channel is in a totem-pole arrangement to minimize cross-conduction. Typically, the turn-on delay of each channel is 120 nsec, and the turn-off delay is 94 nsec. The matching differential for the two channels is ±10 nsec. The drivers feature a typical switching time of 25 nsec into a 1000-pF load—an important consideration when driving power MOSFETs at high frequencies.

Because these devices can work off-line, you can use the floating channel of one to drive an N-channel power MOSFET or insulated-gate bipolar transistor (IGBT) in a high-side configuration that operates off high-voltage rails as high as 500 or 600V. The low-side channel, which is referenced to ground, operates from a fixed supply in the 10 to 20V range. Other features of these versatile devices include CMOS Schmitt-triggered inputs with hysteresis and pull-down, cycle-by-cycle edge-triggered shutdown logic, and undervoltage lockout with hysteresis for both channels. In 14-pin DIPs, the IR2110 and SP606 both sell for about $7

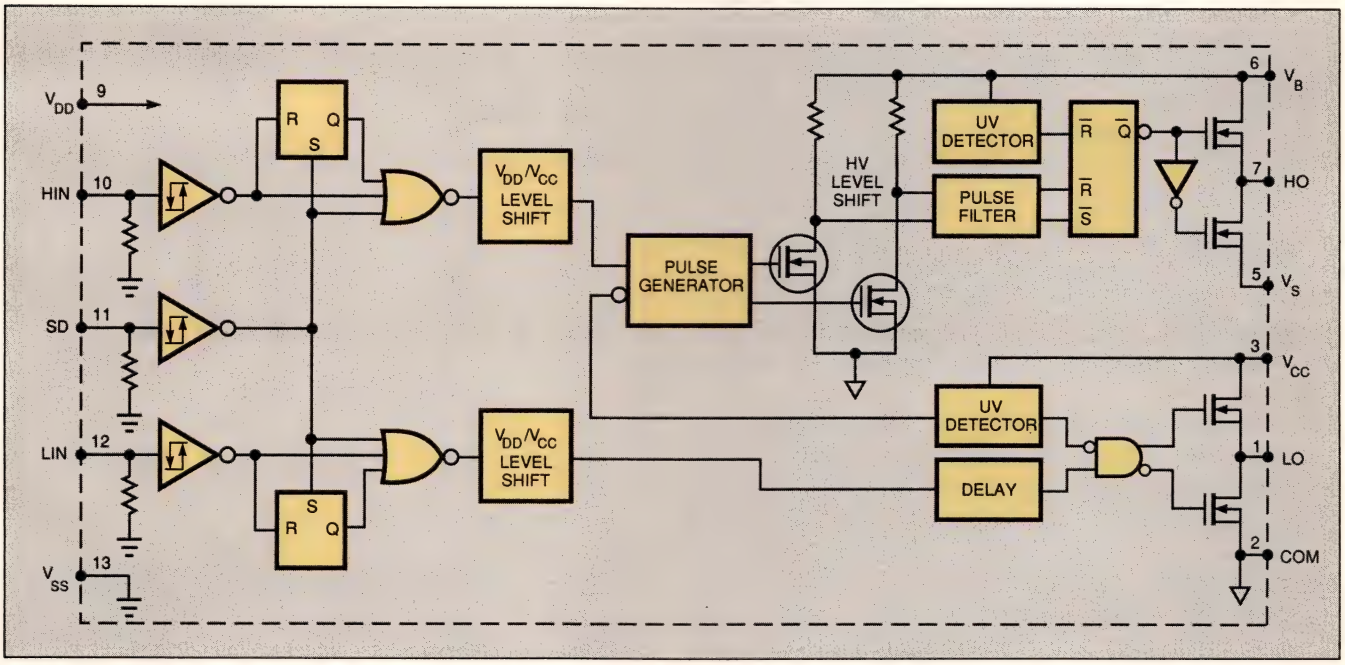


Fig 1—Combining low-voltage bipolar and CMOS devices with high-voltage DMOS output devices, *the IR2110 half-bridge driver from International Rectifier and the SP606 pin-compatible equivalent from Harris Semiconductor easily qualify as smart-power ICs. With a high-side driver rated at 500 or 600V and an independent low-side driver, the totem-pole output stages provide a 2A drive for external power MOSFETs or IGBTs. Other features include Schmitt-triggered inputs, cycle-by-cycle shutdown logic, and undervoltage lockout.*

(1000). The IR2110 is also available in die form at $7.70 each in 100-piece waffle packs.

Although the IR2110 and SP606 half-bridge drivers easily have the intelligence to qualify as smart-power devices, the PWR-82331 3-phase bridge from ILC Data Device Corp falls into the gray area. With a 200V, 30A rating, the device leaves no room for argument as to its power capability. However, its intelligence is only marginal—albeit critical to the proper operation of the circuit.

Low-side versus high-side switching

In a low-side switch (**Fig Aa**), the output driver, or switch, is connected between ground and one end of the load; the other end of the load is connected to the positive rail. In a high-side switch (**Fig Ab**), the driver is connected between the positive rail and one end of the load; the other end of the load is connected to ground.

High-side switches often find use in automotive applications, where having one end of the load connected to a common metallic ground such as the engine or chassis is often desirable. One possible exception is dashboard lighting and instrumentation. Most modern automobiles have dashboards made of plastic or fiberglass, which don't provide a common ground. In these cases, a wired ground is usually necessary, and the designer has the option of using either a low-side or a high-side switch.

From the standpoint of processing technology, fabricating a low-side driver is easier and often less expensive than fabricating a high-side driver. IC manufacturers could fabricate a high-side driver using a pnp open-collector bipolar transistor or a P-channel open-drain MOSFET, but these devices have disadvantages when compared with their npn and N-channel counterparts. For example, the h_{FE} of a pnp transistor is much lower than that of an equal-size npn transistor. Similarly, a P-channel MOSFET has a much higher $r_{DS(ON)}$ than does an equal-size N-channel device. The real-estate penalty incurred by using P-type devices of acceptable performance is one that IC manufacturers are reluctant to pay.

To overcome these problems, manufacturers of high-side drivers have turned to IC designs that integrate an N-channel open-source MOSFET with a voltage-multiplier charge pump. The charge pump forces the N-channel MOSFET to turn on by raising the MOSFET's gate voltage at least 5V higher than its source voltage—a condition that requires a voltage higher than that of the supply line. The basic charge-pump circuit (**Fig Ac**) operates in the following manner: With switch S_1 connected to ground, C_1 charges through D_1 to the supply voltage. The switch then connects to the positive side of the supply, which causes C_1 to transfer its charge through D_2 to C_2. A built-in oscillator causes the switching circuit to repeat the process until C_2 charges to a value equal to V_{DD}. Neglecting switch and diode losses, the voltage doubler in **Fig Ac** will cause V_{OUT} to reach $2V_{DD}$. A zener-diode clamp is often needed to prevent V_{OUT} from exceeding the MOSFET's gate-breakdown voltage. Along with the oscillator and switching circuit, some monolithic ICs also include the charge-pump capacitors.

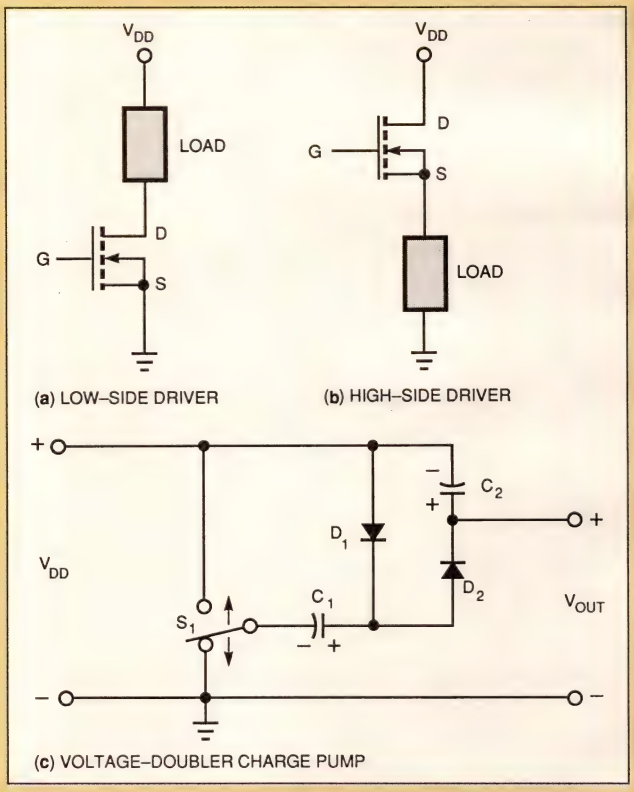
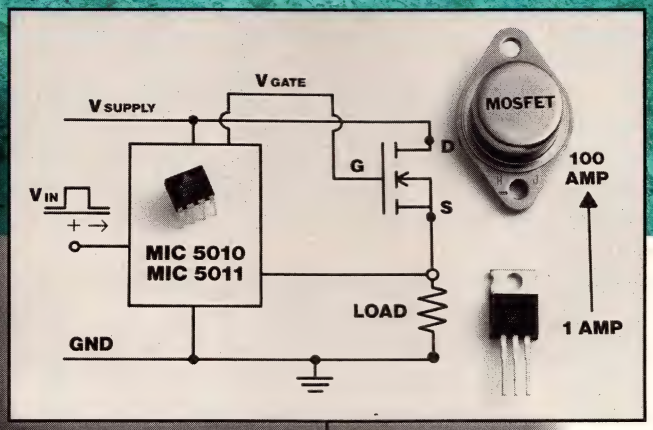


Fig A—In a low-side driver (a), *the load is connected between the supply voltage and the drain of the MOSFET. In a high-side driver* ***(b),*** *the load is connected between the source of the MOSFET and ground. High-side drivers are useful in driving loads that have one end connected to a common (ground) return. In a high-side driver using an N-channel MOSFET, you need a charge pump* ***(c)*** *to raise the MOSFET's gate voltage higher than its source voltage.*

ASISmart Power™ Solutions

One size drives all FETs.



Micrel's new MIC5010/5011 predrivers for N-channel power MOSFETs provide the universal solution to high side switching and power control. "One size drives all FETs." The ICs are fabricated using a proprietary 50 Volt, CMOS/DMOS/Bipolar process making them ideal for automotive, avionic, military, and industrial applications where safe high side driving is a must. An internal voltage multiplier supplies gate voltages greater than VDD. That means you get more effective use of available N-channel power MOSFETs, and lets you take advantage of current price competition for the most cost effective design. Micrel's new predrivers are excellent candidates to replace costly pulse transformers or P-channel devices.

MIC5010/5011 Key Features:

- *Integral voltage pump for gate drive greater than VDD in both high and low side drive applications*
- *Programmable over-current-sensing shut-off comparator detects short circuit condition at the load and latches gate drive off until reset*
- *Wide power supply range (5V to 32V operating, 50V max)*
- *Option pins permit use of external caps to boost drive speed and power*
- *Fault detect and power on reset*
- *Over temperature sense and shutdown circuitry*

The MIC5010BN is available in a 14 lead DIP and the MIC5011BN in an 8 pin DIP. Both parts operate from −40°C to +85°C. Commercial pricing at the 100 piece level is $2.25 for the MIC5010 and $1.95 for the MIC5011. Come to Micrel for ASISmart Power Solutions. For details contact: Micrel Semiconductor, 560 Oakmead Parkway, Sunnyvale, CA 94086. Or call (408) 245-2500.

MICREL SEMICONDUCTOR

The brains behind ASISmart Power.™

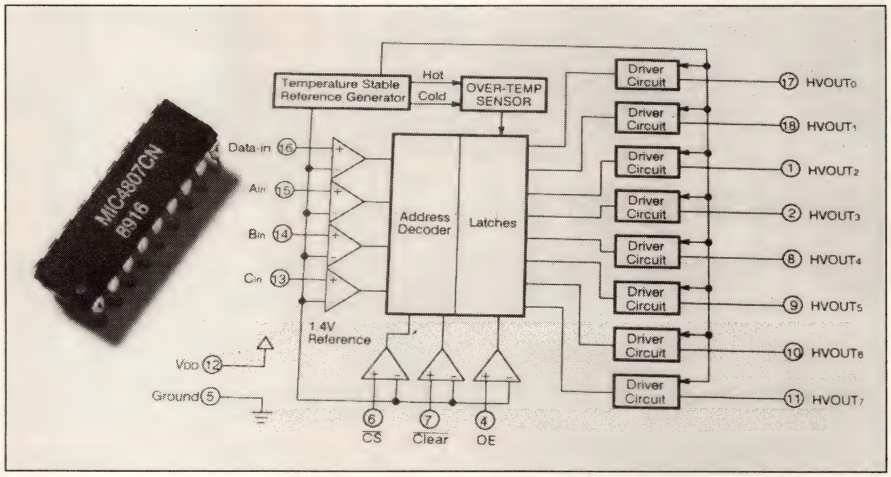
Smart-power ICs

Designed for high-power motor drive applications in missiles and avionics systems, the 82331 hybrid circuit has six N-channel power MOSFETs and six fast-recovery diodes connected in a 3-phase bridge arrangement. A ground-referenced input signal drives each MOSFET through level-shifting circuitry that does not require any external bias voltages. Internal protection circuitry prevents the simultaneous conduction of in-line transistors. An external-shutdown input allows the fast turn-off of the 3-phase output stage.

You can interface the 82331 directly to a motor controller. The device uses a constant-voltage drive, which ensures that the drivers perform uninterrupted—even in a motor-stall situation. Manufactured in accordance with MIL-M-38510 and MIL-STD-883C, the hybrid is expensive: Unit pricing starts at $1150. But if you need the high-power, high-efficiency, and high-frequency capabilities that this device offers, you have few other choices. Whether the device is intelligent is open to individual interpretation.

Other devices whose intelligence is open to debate but is sufficient for the intended application include the UDN2547 quad driver from Sprague, the TPIC2404 quad driver from Texas Instruments, and the MIC4807 8-channel driver from Micrel. The Sprague and TI devices are fabricated in a bipolar process; the Micrel device is fabricated in a combined CMOS/DMOS process. All of these multichannel devices are low-side drivers that are suited for driving incandescent lamps in automotive display applications.

Sprague's UDN2547 has four single-ended bipolar output drivers, each of which can deliver an output of 40V and 600 mA. Protection circuitry limits each driver's short-circuit output current to 1.3A and provides a shutdown function when the junction temperature reaches approximately 165°C. Normal operation returns when the temperature falls to approximately 150°C. The device can drive incandescent lamps without limiting resistors. The quad driver is available in a 16-pin DIP or a 28-pin plastic leaded chip carrier (PLCC) for $2.09 and $2.52 (1000), respectively.



This smart-power device contains eight open-drain MOSFET drivers, *which are controlled by addressable latches. Each channel of the MIC4807 from Micrel Semiconductor can operate to 80V and 100 mA. The IC limits short-circuit current to 200 mA, and a thermal-shutdown feature provides protection against sustained fault conditions. The IC also has an output-enable pin, which you can use in conjunction with an external PWM to control each channel's output current.*

The TPIC2404 from Texas Instruments is also a 4-channel driver but can handle somewhat higher current than can the Sprague device. Rated at 45V and 1A per channel, the device features independent thermal shutdown, overvoltage shutdown, and current limiting. It also includes output clamp diodes for protection against transients when switching inductive loads. Packaged in a 15-pin power SIP (single-in-line package), the quad driver can dissipate 2.5W at a free-air temperature of 25°C and 50W at a case temperature of 25°C. The device costs $4.83 (1000).

The MIC4807 from Micrel Semiconductor has eight open-drain, N-channel MOSFET drivers, which are controlled by addressable latches. Each channel can operate to 80V and deliver an output of 100 mA. A built-in current limiter holds the short-circuit current to about 200 mA. A thermal-shutdown circuit protects the device against sustained fault conditions by shutting off the outputs when the die temperature exceeds 150°C. The device also has an output-enable pin, which you can use in conjunction with an external PWM circuit to control the output current of each channel. This feature is particularly useful when you need to control the brightness of incandescent lamps. In an 18-pin DIP, the device costs $3.95 (100).

Some people might question the intelligence or power capabilities of certain devices touted as smart-power ICs, but the L6280 from SGS-Thomson is not likely to be one of those devices. Originally developed as a single chip to provide motor drive, hammer drive, and a μP interface for an electronic typewriter, this 3-channel device certainly has both brains and brawn.

Fabricated in 60V bipolar, CMOS, and DMOS, the L6280 integrates two 1A motor drivers, a 3A solenoid driver, a 5V/1A switching



IF YOU'VE HEARD IT'S IMPOSSIBLE, YOU HAVEN'T HEARD FROM SEMIKRON.

Semikron can nearly always solve your power semiconductor problems.

Will a standard power semi meet your needs? We make thousands of different types. And we can make many modifications to our standard devices to match your precise requirements. Plus, we'll build complete stack assemblies including heat sinks, fans, fuses, and more.

Semikron invented the Semipack™ isolated thyristor/diode module, still the world standard. We continue innovating, with new thyristors, Darlingtons, MOSFETs, IGBTs, and advances in package densities, switching speeds, blocking voltages, and current ranges.

No one else has our depth of technical experience. Put us to the test.

SEMIKRON, INC., 11 Executive Drive, Box 66, Hudson, NH 03051
TEL: (603) 883-8102 • TOLL FREE 800-258-1308 • FAX: (603) 883-8021

CIRCLE NO. 54

Smart-power ICs

power supply, and a μP interface on a single monolithic chip. Connecting directly to a μP bus, the μP controls the chip as it would a microperipheral. Commands loaded into internal registers control the device's power-driving circuits, allowing software to manage current control. You can also use software controls to set the device's operating modes—even the configuration of the output stage. For example, you can program the motor drivers to drive a stepper motor or a dc motor.

The device also has many protection features, such as internal logic that protects the device against potentially damaging software errors. Other such features include power-fail, thermal, and overcurrent protection. A watchdog controller protects against CPU failure without losing data. Because of the chip's high efficiency, its power dissipation is low. As a result, the manufacturer was able to put the chip in a 44-pin PLCC without any need for heat sinking. The L6280 sells for $9 (1000).

Completing this roundup of smart-power ICs are a pair of highly specialized standard products from Power Integrations Inc and Power Trends Inc and a versatile semicustom device from Cherry Semiconductor Corp.

The PWR-SMP3 from Power Integrations is a 1-MHz power-supply IC that you can use to construct a 3W off-line isolated supply. You can connect the device directly to a rectified 115V ac line or to a high-voltage dc bus of 200V max. The monolithic IC combines a 350V power MOSFET with a complete switch-mode PWM control system. The MOSFET features a low on resistance and low input and Miller capacitances. The controller section includes a start-up preregulator, a PWM oscillator operating at 1 MHz, a bandgap reference, an error amplifier, and a gate driver. Other features include overvoltage and undervoltage lockout, high-speed current limiting, and over-temperature protection.

The PWR-SMP3 also includes feedback and compensation networks, which eliminate the device's need for additional external components. Operating at a switching frequency of 1 MHz, the device significantly reduces the required size of the external output transformer and capacitor. You can fit the IC and all external components into a 3-prong plug. The device is packaged in a 16-pin power DIP and costs $6 (1000).

Power Trends Inc offers a line of integrated switching regulators. Initially available in 1.5A versions, these 1-MHz, 3-terminal regulators provide drop-in replacements for the popular 78 series of TO-3 and TO-220 linear regulators. The hy-

For more information . . .

For more information on the smart-power ICs discussed in this article, circle the appropriate numbers on the Information Retrieval Service card or use EDN's Express Request service. When you contact any of the following manufacturers directly, please let them know you saw their products in EDN.

Cherry Semiconductor Corp
2000 S County Trail
East Greenwich, RI 02818
(401) 885-3600
Circle No. 663

Harris Semiconductor
Smart Power Operations
Box 13996
Research Triangle Park,
NC 27713
(919) 361-1600
Circle No. 664

Hitachi America Ltd
Semiconductor & IC Div
2000 Sierra Point Pkwy
Brisbane, CA 94005
(415) 589-8300
Circle No. 665

ILC Data Device Corp
105 Wilbur Pl
Bohemia, NY 11716
(516) 567-5600
Circle No. 666

International Rectifier Corp
233 Kansas St
El Segundo, CA 90245
(213) 607-8900
Circle No. 667

Linear Technology Corp
1630 McCarthy Blvd
Milpitas, CA 95035
(408) 432-1900
Circle No. 668

Micrel Semiconductor
560 Oakmead Pkwy
Sunnyvale, CA 95086
(408) 245-2500
Circle No. 669

National Semiconductor
2900 Semiconductor Dr
Santa Clara, CA 95052
(408) 721-5000
Circle No. 670

Power Integrations Inc
411 Clyde Ave
Mountain View, CA 94043
(415) 960-3572
Circle No. 671

Power Trends Inc
1020 Carolina Dr
W Chicago, IL 60185
(708) 231-5505
FAX (708) 231-5577
Circle No. 672

SGS-Thomson Microelectronics
1000 E Bell Rd
Phoenix, AZ 85022
(602) 867-6100
Circle No. 673

Siemens Components Inc
Semiconductor Group
2191 Laurelwood Rd
Santa Clara, CA 95054
(408) 980-4500
Circle No. 674

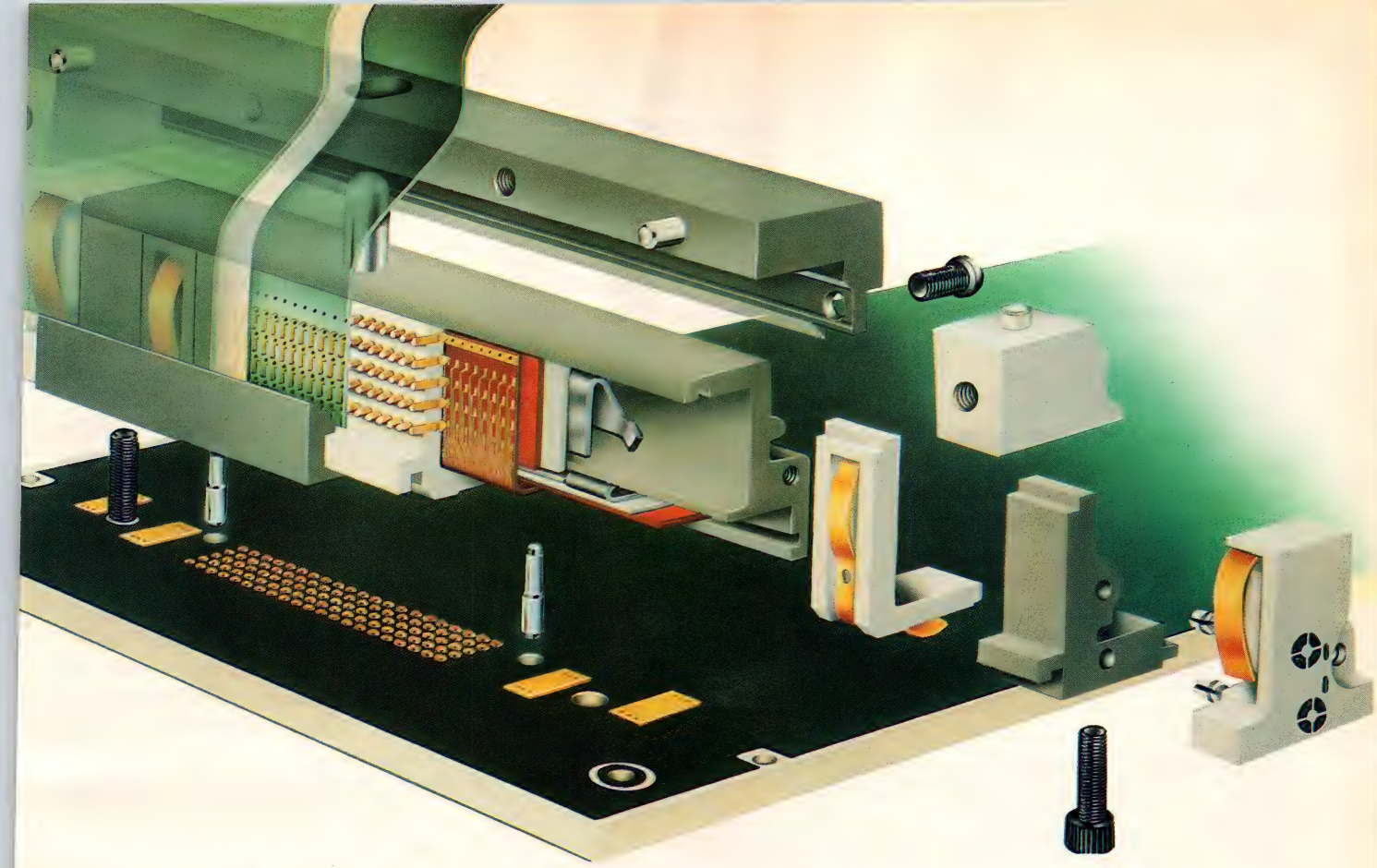
Sprague Semiconductor Group
363 Plantation St
Worcester, MA 01605
(508) 795-1300
Circle No. 675

Texas Instruments Inc
Semiconductor Group
Box 809066
Dallas, TX 75380
(800) 232-3200
Circle No. 676

VOTE . . .

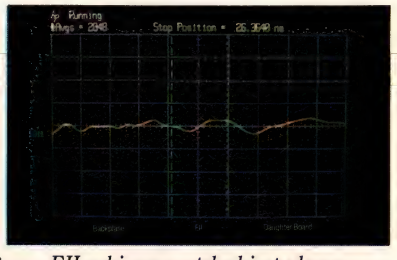
Please also use the Information Retrieval Service card to rate this article (circle one):

High Interest 518
Medium Interest 519
Low Interest 520



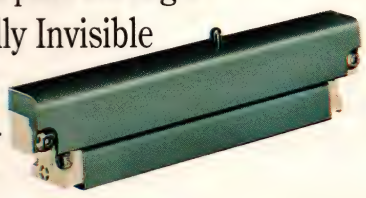
Out of sight performance!

Introducing the Electronically Invisible Interconnect: transparent to high frequency signals, therefore eliminating connector induced signal distortion. Until now, the limiting factor for signal integrity in high speed electronic circuits has been the connector. The source may be matched to the load, but an impedance mismatch at the connector degrades performance. Signal integrity through EII is maintained because reflection, crosstalk, attenuation, signal skew, and rise-time degradation are reduced to absolute minimums.



EII achieves matched impedance of the connector to the backplane and daughter card.

This unprecedented performance is made possible by a unique flexible microstrip transmission line structure with a continuous ground-plane as the major signal path through the Electronically Invisible Interconnect. Augat, the company known for quality and innovation, is now setting a new standard of performance – the Electronically Invisible Interconnect. Outta' sight!



AUGAT® *Quality and Innovation*

Augat Inc., Interconnection Products Division
33 Perry Ave., P.O. Box 779,
Attleboro, MA 02703
(508) 222-2202
FAX: (508) 222-0693

brid devices integrate a control IC, a FET, a Schottky diode, and an inductor, and provide constant-frequency current-mode control. The devices are $0.85 \times 0.85 \times 0.25$ in. and require much less board space than conventional devices. They feature an efficiency of more than 85% and have power densities of 40 to 200W/in^3. Available in eight voltages from 5 to 24V, the 1.5A devices cost $12 (1000). Power Trends expects to introduce 3 and 5A versions.

In addition to the multitude of standard smart-power devices, you have the option of purchasing a custom device—provided the expected production quantities justify the development costs. Indeed, many system designers with large-volume applications take the custom route rather than use a standard device, which may not provide the exact performance they need. In many cases, however, a semicustom circuit can fit the bill. When quantities can't justify the cost of a custom circuit and a standard product doesn't quite meet the designer's objectives, a semicustom circuit can often bridge the cost-performance gap.

The 6000 series of semicustom devices from Cherry Semiconductor Corp is a good example of the inherent versatility of this type of device. The 6000 array contains two monolithic chips in either a 15-lead Multiwatt package or a 20- or 24-lead batwing SO package (**Fig 2**). One of the chips integrates two power npn transistors, each rated at 50V and 2.5A. The transistors feature a typical h_{FE} of 80 and a $V_{CE(SAT)}$ of 0.75V at a collector current of 2A. Connected in parallel, the two transistors can sink as much as 5A to an external load.

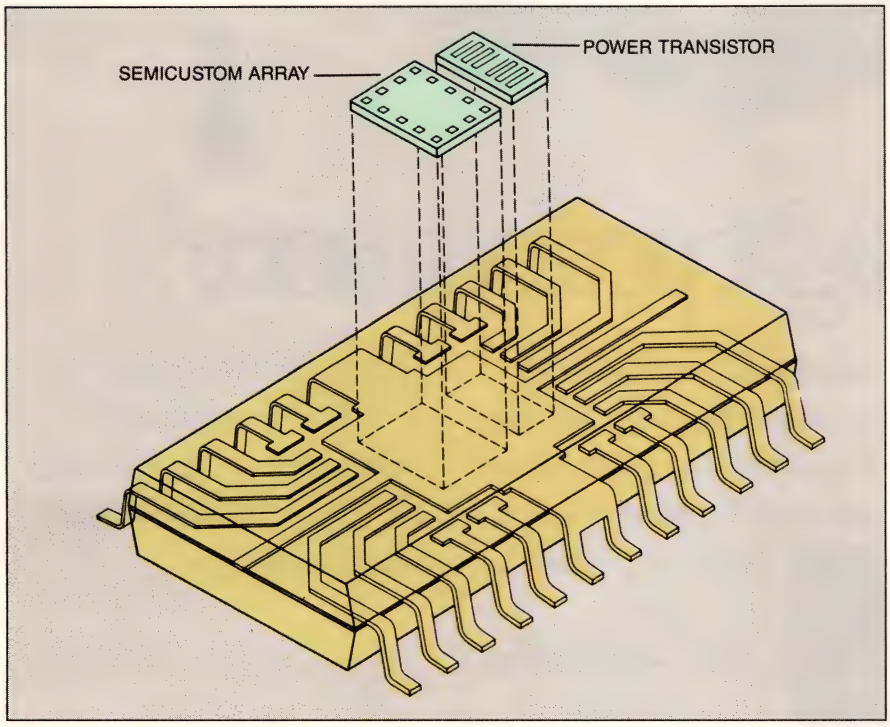


Fig 2—Combining a 2-transistor power chip with the versatility of a semicustom array, *the Genesis 6000 from Cherry Semiconductor offers an alternative to standard smart-power products. The device shown is in a 24-lead SO package. Other package options include 20-lead SO and 15-lead Multiwatt.*

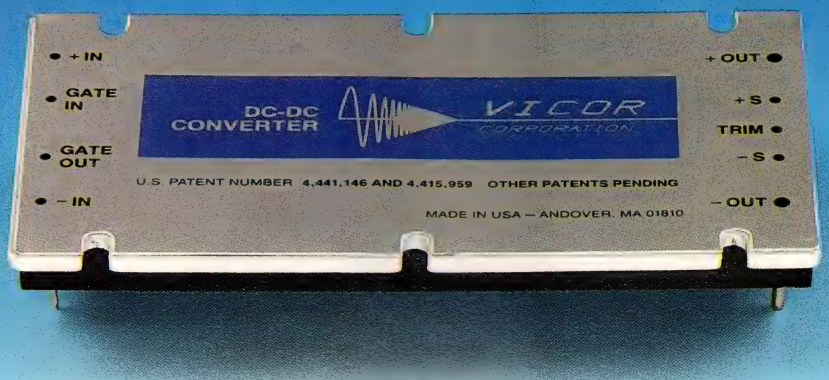
The second chip can be any one of 12 linear or linear/digital chips in the company's family of semicustom circuits. By choosing the 1500 linear/digital array, for example, you'll have 98 I^2L logic gates, 198 linear transistors, and 462 diffused resistors with which to design the "smart" portion of a smart-power circuit. By choosing the 5000 linear-only array, you can implement signal processing and power capabilities that require as many as 314 small- and medium-sized npn and pnp transistors and 858 diffused resistors. Using uncommitted semicustom arrays, you can easily include on-chip protection features such as overvoltage and undervoltage shutdown, current limiting, and thermal shutdown.

The versatility provided by the 6000 2-chip array lets you quickly implement semicustom smart-power circuits for a variety of automotive, motor-control, and power-supply applications at a fraction of the development cost usually assotciated with a custom circuit. Although pricing varies according to the array and package options, a typical cost for the 6000 in an SO package is $3 (1000).

Today's crop of smart-power ICs does not represent a harvest that provides an answer to every problem, but it does offer a wide variety of products from which to choose. As manufacturers continue to enhance their processing technologies, you can expect to see even greater improvements in device performance and innovation. EDN

Article Interest Quotient
(Circle One)
High 518 Medium 519 Low 520

1985 : smallest



VI-100 family
4.6" x 2.4" x 0.5"
50, 75, 100 Watts

1990 : smaller



VI-200 family
4.6" x 2.4" x 0.5"
50, 75, 100, 150, 200 Watts



MiniMod™ family
2.28" x 2.4" x 0.5"
25, 50, 75, 100 Watts

1-800-735-6200

Component Solutions For Your Power Systems
23 Frontage Road, Andover, MA 01810

VICOR

Gourmet Capacitors at Fast-Food Prices

High-performance mini-capacitors from *TOKIN*



There's no question that TOKIN's new chip-type high-capacitance multilayer ceramic capacitors are earning a loyal following. Suddenly, one can find them in the fanciest equipment and devices in town, and with good reason. One explanation is their large permittivity (capacitance). Another is *size*—only 1/5 that of conventional products.

And to clinch the ideal, they can be had for a very competitive price.

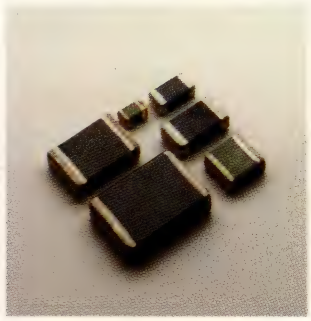
The story doesn't end there, though, because these gourmet capacitors are ideal for surface mounting and offer outstanding reliability.

TOKIN was able to accomplish all this by firing two special materials with different temperature characteristics at a low temperature (less than 1,000°C), thereby increasing capacitance while cutting costs. A dramatic breakthrough in capacitor technology.

What's more, you can put these devices to work in a wide range of application including EMI/EMC filters and bypass capacitors.

Compact and high performance at budget prices, who could refuse?

Call us today.



New Multilayer Ceramic Capacitor

		25V10μF		25V22μF	
		Dimensions (mm)	Case Code	Dimensions (mm)	Case Code
NEW	Y5U	2.7×5.7×2.5	SD	5.0×5.6×2.5*	SE
CONVENTIONAL	Y5U	6×10×3.0	SB	—	
	Y5V	4×8×2.5	SA	6×10×3.0	SB

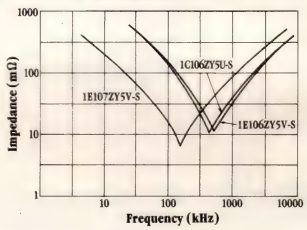
*The product is in the experimental stage.

Ceramic Capacitor End Termination

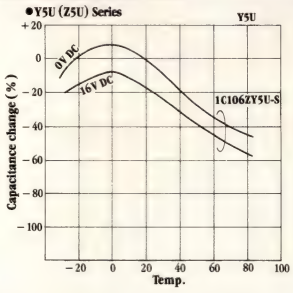
Nickel/Tin Plate Termination*1	1E106ZY5U-SD
Fired-on End Termination	All Case Code

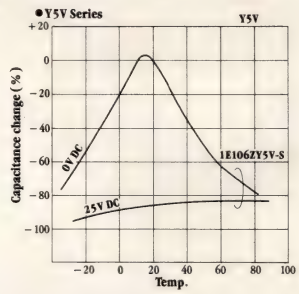
*1 The product is in the experimental stage.

Frequency Characteristics



Stability at Low and High Temperatures





Characteristics

	Temp. Characteristics Y5U (Z5U)					Temp. Characteristics Y5V			
	25 Model	16 Model	25 Model	75 Model		25 Model	50 Model	75 Model
10μF	1E106ZY5U-SD*1	1C106ZY5U-SB	1E106ZY5U-SB	1N106ZY5U-SC	10μF	1E106ZY5V-SA	1H106ZY5V-SB	1H106ZY5V-SC
18μF	—	1C186ZY5U-SB	—	—	22μF	1E226ZY5V-SB	1H226ZY5V-SC	—
22μF	1E226ZY5U-SE*2	—	—	—	47μF	1E476ZY5V-SB	—	—
33μF	—	1C336ZY5U-SC*3	—	—	100μF	1E107ZY5V-SC	—	—

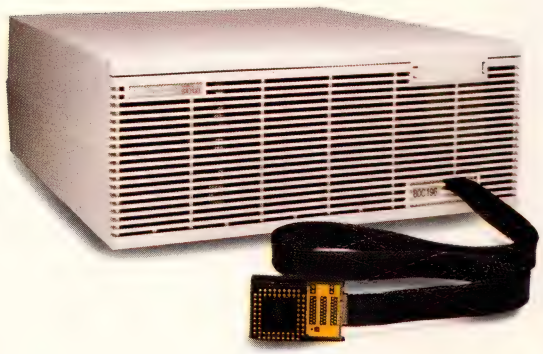
*1 New product *2 The product is in the experimental stage. *3 SC: 8×12×3.5mm

TOKIN

Tokin Corporation
Hazama Bldg., 5-8, Kita-Aoyama 2-chome, Minato-ku, Tokyo 107, Japan
Phone: 03-402-6166 Fax: 03-497-9756 Telex: 02422695 TOKIN J

Tokin America Inc.
155 Nicholson Lane, San Jose, California 95134, U.S.A.
Phone: 408-432-8020 Fax: 408-434-0375
Chicago Branch
9935 Capitol Drive, Wheeling, Illinois 60090, U.S.A.
Phone: 708-215-8802 Fax: 708-215-8804

This box kills bugs, does impersonations and takes you to market at exhilarating speeds.



©1990 Hewlett-Packard Company CCEG 003

New microprocessors come out frequently. Emulators don't. And when they finally do, you're forced to rush your design to keep up with the competition.

Hewlett-Packard has a better way.

The HP 64700 Series of emulators. Now you'll have your design to market much faster. Because now you'll have a tool that allows you to design with the latest chips the moment they hit the market. All thanks to our new agreements with key chip vendors. In fact, some of our latest emulators include the Motorola 68332, AMD 29000, AT&T DSP32C and National Semiconductor 532.

The HP 64700 Series is easier than ever to learn and use. Our new user interface simplifies debugging and analysis.

See how the HP emulator can help cut your time to market. Call us at 1-800-752-0900, Ext. 1298.

There is a better way.

HEWLETT PACKARD

*"WE DEPEND ON **EDN'S MAGAZINE** AND **NEWS EDITIONS** TO DELIVER THE SPECIFICS ON MAXIM PRODUCTS TO POTENTIAL CUSTOMERS."*

Mike Dikas
Director of Communications
Maxim Integrated Products

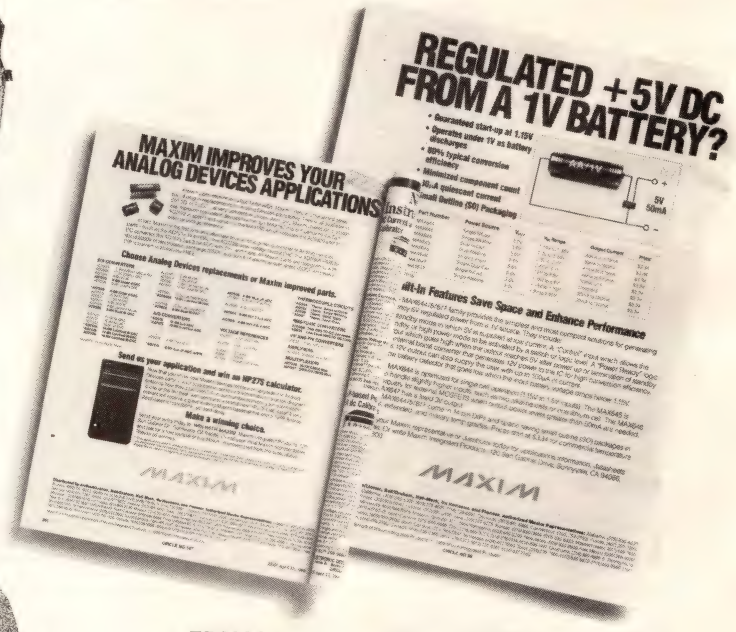
Maxim Integrated Products is one of today's fastest growing international suppliers of quality analog ICs. In the past five years they have introduced more than two hundred proprietary and improved second source devices.

Director of Communications, Mike Dikas has piloted Maxim's advertising program since its inception. "EDN's magazine and news editions have played a significant role in introducing many of our new products. In the past two years, over 25,000 EDN Magazine and News Edition readers have responded to Maxim ads, product releases and articles," says Mike. "Our ads consistently fall in the top 10% in reader response in both editions of EDN. What's even more amazing is that we typically get less than 5% duplication of responses to the same ad in both the Magazine and News Editions."

What's that mean for Maxim? "Since both editions deliver the same circulation, it's apparent to us that the same engineers read both the Magazine and News Editions for different reasons. Given Maxim's charter of product proliferation, EDN's in-depth coverage of technical issues and timely coverage of new products are both of the utmost importance to Maxim."

Mike Dikas believes in the complementary roles of EDN Magazine and EDN News Editions.





EDN Magazine and News Editions work for Maxim Integrated Products.
They can work for you.

EDN

A Partnership in Power and Prestige Worldwide.

DUPONT PIXEL SYSTEMS

The dumbest VME framestore in town may be the most intelligent choice for X-Windows

X-Windows is rapidly becoming a de facto industry standard. Thanks to X, we no longer have to provide old-fashioned terminal interfaces or struggle with writing a windowing system from scratch. Instead, we can concentrate on our application software and provide a modern user interface with the tools X provides.

The problem with most VME graphics boards is that they provide too many features which are of little use with X. With Xframe™ we chose to do things differently. We started with X-Windows software and worked back to the simplest hardware architecture necessary to run X efficiently. As a result, Xframe™ offers colour X performance levels much greater than most workstations. Yet, it costs very little and can be integrated into your VME system with ease. All you need is a UNIX host and a robust C compiler. We can also offer guidance should you need it.

Xframe™ has a displayed resolution of 1024 x 768 pixels, with 4-bits or 8-bits per pixel. Up to 256 colours from a palette of 16 Million are displayable. It comes complete with an Xframe™ optimised X.11.4 server on the SUN-3. The source code for this server is available separately for you to use as an example. So if you are an OEM or VAR needing X on VME, and enjoy simple solutions, give us a call.

Xframe™ – The dumb framestore for X-Windows

0800·181·354

Available Now

DU PONT PIXEL SYSTEMS LIMITED,
Benchmark House, 203 Brooklands Road, Weybridge,
Surrey, England KT13 0RJ. Telephone (44) 0932 850050
Trademarks: We acknowledge the use of all trademarks.

DU PONT



EDN INFO CARDS

THE 2¢ SOLUTION

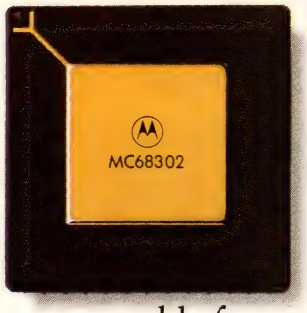
to your marketing budget blues– the EDN Info Card Pack. At 2¢ per name, the EDN Info Card Pack can reach over 123,000 engineering specifiers affordably.

Call Donna Pono at (617) 558-4282 for details.

EDN Magazine Edition / News Edition

A Partnership in Power and Prestige Worldwide

INTRODUCI
GREAT COM



Quick, who was the last "great communicator?" Ah, well, it doesn't matter. Not even he controlled the world of communications as well as you can now.

And with a single chip, at that. Namely, Motorola's 68302 Integrated Multiprotocol Processor.

CONTROL ALL FORMS OF COMMUNICATIONS.

That's a big promise, but the 68302 is more than up to it. With three high performance serial communications controllers, each with multiprotocol capabilities, the 68302 can run anything from ISDN, WANs and packet networks to bridges, concentrators, gateways, peripheral I/O, modems and more.

ISDN, by the way, leads that list for a very good reason. Because the 68302's multiprotocol capabilities are the first sensible way to migrate today's proprietary and defacto protocols to emerging standards like ISDN.

RUN ON A POWERFUL 68000 PLATFORM.

The 68302 operates on a 68000-based core and it's fully compatible with the wide world of existing 68000 software. And with our growing 68300 family of microcontrollers.

All that compatibility, obviously, can save you loads of development time and lots of money.

In addition to the 68000-core processor, the 68302 features a powerful, high-speed RISC-based communications processor.

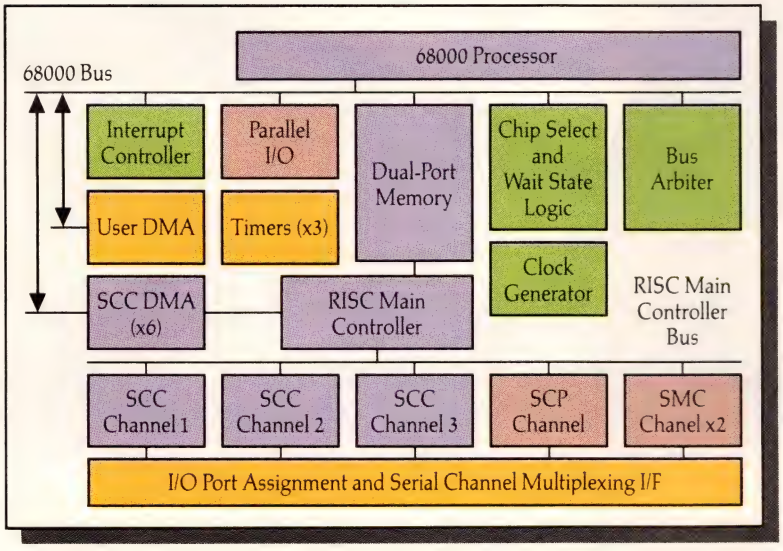
This dual processor approach yields efficient communications processing. Not to mention the highest performance communications controller on the market.

Winner 1988 Malcolm Baldrige National Quality Award

NG THE NEXT MUNICATOR.

NOW A WORD ABOUT THE ECONOMY.

To save you even more money (and a bit of board space), the 68302 is the most highly integrated communications controller around. In addition to its mighty processors, it comes with a system integration module that's loaded with system glue logic (see diagram for details) you'd otherwise have to provide yourself.



COMMUNICATE TOLL FREE.

So whether you're designing for ISDN or any other form of communication, you simply can't do any better than the 68302.

For more information on the 68302, the third-party support behind it, and our 68302 Application Development Systems Evaluation Board, call 1-800-441-2447. Or contact the Motorola Semiconductor sales office nearest you.

It's sure to be the start of some great communication.

MOTOROLA

© 1989 Motorola Inc.

Tek's 40 GHz
All tied



Copyright © 1989 Tektronix, Inc. All rights reserved. 118X-006

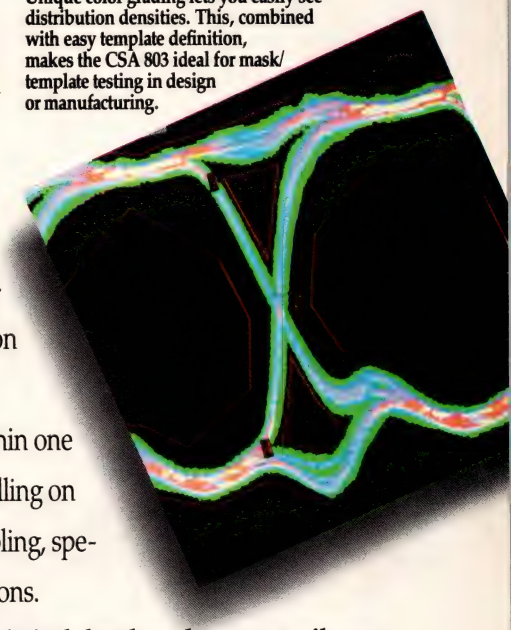
communications test system. up in one neat package.



Introducing the Tek CSA 803 Communications Signal Analyzer. As of now, working with high-speed optical and electrical signals is no reason to go to pieces.

Now you can fully experience a real-time feel for waveform throughput and manipulation. Do in-depth statistical analyses of noise and jitter. Trigger on signals of up to 10 GHz. Do on-board mask testing, constellation diagrams, and more.

And, you do it all from within one tailored instrument, without calling on external computers, clumsy cabling, specialized software or costly add-ons.



Unique color grading lets you easily see distribution densities. This, combined with easy template definition, makes the CSA 803 ideal for mask/template testing in design or manufacturing.

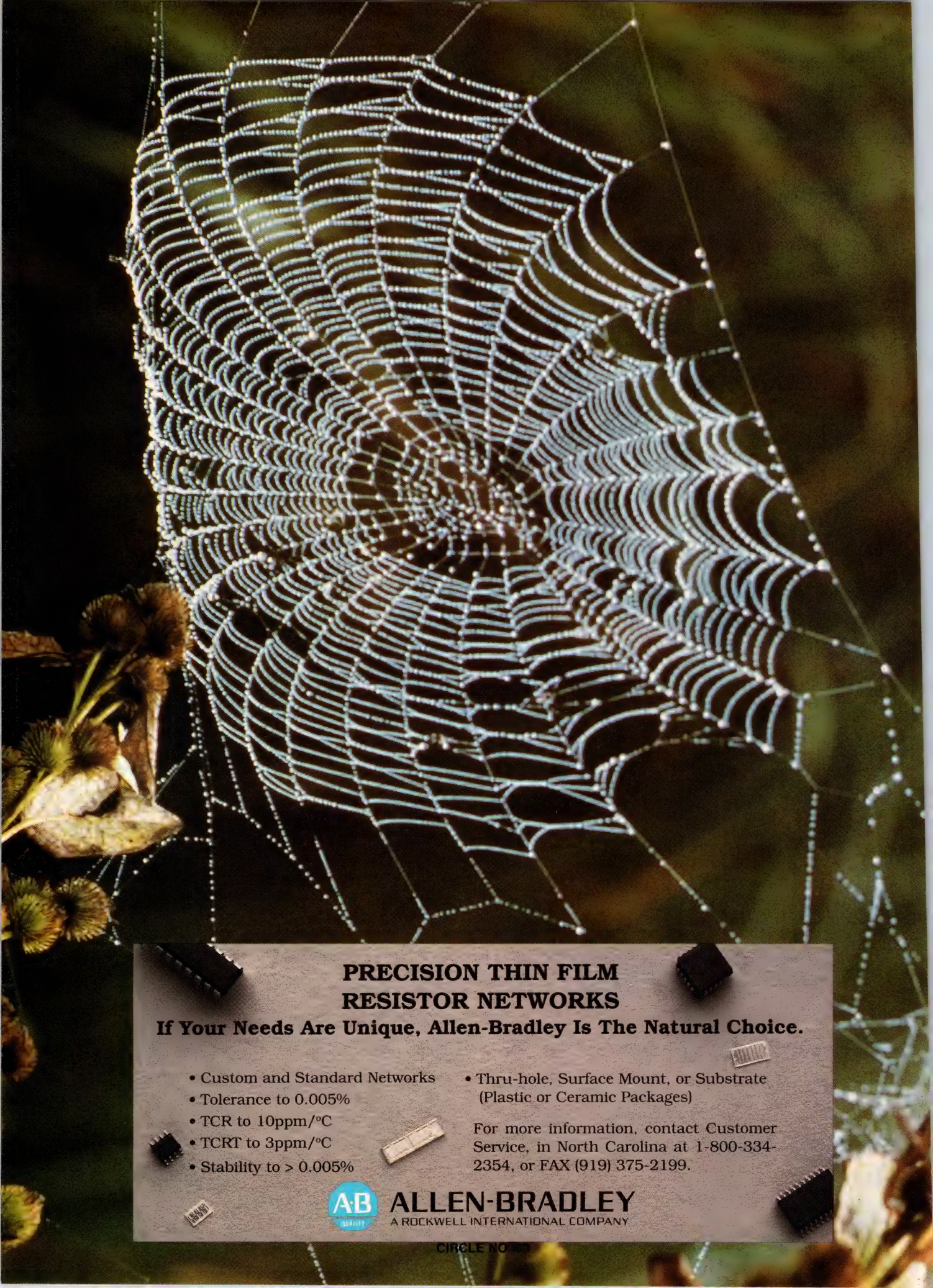
A powerful on-board statistical data base lets you easily see data distribution densities via color-graded displays. For the first time, you can generate jitter and noise histograms without reacquiring data... and enjoy continuously updated statistical readouts of mean, RMS deviation and p-p at the same time. A sample rate 20 times faster than its nearest competitor lets you analyze data concurrent with acquisition.

You can define, edit and store masks for tolerance testing: the CSA 803 automatically counts the samples that fall within each mask. Constellation diagrams, for qualitative digital RF testing, are also provided.

Easily expand to meet your needs and new evolutions of technology. Start with one channel if you wish, and add more channels up to a total of four. Choose from a large and still-growing selection of plug-in sampling heads, optimized for your application. The CSA's modular design lets you upgrade without adding an inch to its footprint.

Call 1-800-426-2200 for the complete CSA 803 story. Or let your Tek sales engineer show you the whole package soon.

Tektronix®
COMMITTED TO EXCELLENCE



PRECISION THIN FILM RESISTOR NETWORKS

If Your Needs Are Unique, Allen-Bradley Is The Natural Choice.

- Custom and Standard Networks
- Tolerance to 0.005%
- TCR to 10ppm/°C
- TCRT to 3ppm/°C
- Stability to > 0.005%
- Thru-hole, Surface Mount, or Substrate (Plastic or Ceramic Packages)

For more information, contact Customer Service, in North Carolina at 1-800-334-2354, or FAX (919) 375-2199.

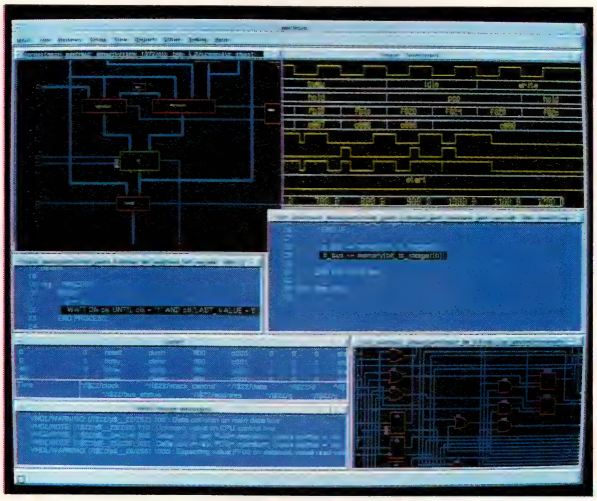
ALLEN-BRADLEY
A ROCKWELL INTERNATIONAL COMPANY

CIRCLE NO. 83

Tabular functional and timing models improve simulator's capability

Keeping your circuit and simulator in RAM is critical to the rapid execution of simulation. Paging parts of the circuit to disk hurts the performance of the simulator. As circuit density and complexity increase, you need to evaluate more gates in the same amount of time to keep pace.

The short-term solution is to add more memory to your workstation, but for the longer term, the gate models need to get smaller. Most simulators use gate models that need from 1000 to 2000 bytes. The recently announced QuickSim II simulator claims to need about 70 bytes.



VHDL demands concurrent execution of circuit models. *Therefore, to debug a design, you may need to view multiple pieces of code executing simultaneously, as in this view of QuickSim II.*

Two techniques accomplish QuickSim II's memory-usage reduction. First, the simulator uses a table-based model, rather than a text-based one. For example, the vendor models a rising-edge-clocked D flip-flop with asynchronous reset using the following table. Where "X" equals "don't care" and "N" equals "no change":

$\overline{R}$	CP	D	Q	::	Q
0	XX	X	X		0
1	01	X	X		D
1	X0	X	X		N
1	1X	X	X		N

The second technique replaces each instance of the model in your net list with the model's current state and a reference to the model's table. You could consider the reference as a pointer or subcircuit call. As a result, the simulator only stores one copy of the actual model and about 70 bytes of state data for each gate instance.

These modeling techniques are largely responsible for allowing a 500,000-gate-equivalent circuit to fit within 64M bytes of memory. The simulator kernel and OS take up about 4M bytes, which leaves you with plenty of memory for the simulation model.

Further performance boosts come from QuickParts II, a compiled logic technique that reduces an arbitrary collection of gates into a single compiled instance. According to the vendor, this technique boosts performance to as much as 100 times that of the gate-level circuit. Another boost comes from the simulator loading your net list directly from the database, rather than expanding it as previous versions of the software did.

Features that complement the performance gain come from the linkage between list, trace, circuit, and message windows. You can, for example, click on a setup-violation message. The software then highlights the message, the violated gate in both the net-list and circuit windows, and the event in the trace window. As a result, you needn't hunt through any of the circuit views to find potential problems.

The simulator's object-oriented database allows independent function and timing models. Also, the timing equations that you write in the company's programming language are usable in functional, timing, and fault simulation, as well as in synthesis and critical-path analysis.

The timing equations can accurately model fan-out loading and input-slew delays. Coupled with the tabular models, they perform piecewise-linear and discrete-value approximations to model nonlinear delays. You can also use these equations to derate the circuit's performance based on temperature and voltage effects. All timing equations estimate prelayout capacitance as a function of fan-out and back-annotate parasitic capacitance from the layout.

The independence of the timing and functional models gives you the ability to simulate at many different levels. For example, you can simulate one piece of the circuit using full timing models while simultaneously using zero- or unit-delay simulation on another piece.

The timing and functional inde-

Maybe it's time for a 16-bit DAC that draws only 2mA.



Our SP9316 knows how to keep its cool. But that's only one of the reasons it's such a hot seller. It also gives you superior accuracy, a 2µs settling time, and two 8-bit input registers that let you use today's popular high-speed microprocessors without all the extra circuitry. And there's more.

MODEL	LINEARITY	MONOTONICITY	POWER SUPPLY	DISSIPATION	µPINTERFACE	STABILITY
SP9316-4	0.006% FSR	14-bits	+15V	30mW	8-bit or 16-bit	0.1ppm/°C
SP9316-5	0.003% FSR	15-bits	+15V	30mW	8-bit or 16-bit	0.1ppm/°C

For a data sheet or samples, contact Sipex GmbH.

Rheinstrasse 32,
6100 Darmststadt
West Germany



Tel: 49-(6151)291595
49-(6151)292713
FAX: 49-(6151)292762
Tlx: 841-419390

Sipex Corporation

SIGNAL PROCESSING EXCELLENCE

CIRCLE NO. 64

pendence also provides the flexibility to support multiple ASIC technologies. Technology files contain technology-specific timing information. You map the appropriate technology file to the logic models for accurate simulation, depending on the technology and feature size the vendor will use to build your ASIC.

As with the most recent incarnations of the vendor's tools, this version offers interactive and incremental circuit updating. Additionally, for changes that affect timing, the software recalculates the delays only for the affected equations. As a result, changing the loading on a gate affects the timing of only that gate; the software won't recalculate all timing equations.

The simulator accepts models of various types to let you use the optimal modeling techniques for your design. You can use primitive gates, hardware models, the vendor's own behavioral language models, and VHDL for any combination of models. And if you do build your design in VHDL, the software doesn't translate the source code; QuickSim II executes it directly.

Though largely rewritten from its previous version, QuickSim II accepts models and run files written for the existing tool. The simulator will be available with the vendor's release 8.0 in the third quarter as a free upgrade to Idea Station users on maintenance. Although pricing wasn't set at press time, the vendor expects Idea Station running 8.0 to be comparable to its 7.0 pricing of $47,000.—***Michael C Markowitz***

Mentor Graphics, 8500 Creekside Pl, Beaverton, OR, 97005. Phone (503) 626-7000.

Circle No. 732

YOUR SINGLE SOURCE MANUFACTURER FOR CLAD METALS & PRECISION STAMPING



COST EFFECTIVE...
- Total SPC Commitment
- Certified Vendor To Electronic's Industry
- Innovative Engineering Support For Clad Prototypes
- Over A Decade Of Service To Fortune 500 Companies

...THE BEST OF BOTH WORLDS

Call/write for free brochure and sample.

26 Precision Drive
Shirley, New York 11967
FAX: 516-924-1007
PHONE: 516-924-1000

PRECISION CONCEPTS, INC.

CIRCLE NO. 65

SCSI INSTRUMENTS



ANCOT's SCSI instruments are powerful, easier to use, and cost less. Proven in use worldwide, Ancot's portable equipment travels from bench to field and back again without ever slowing down. They are time and labor saving instruments, for design, manufacturing, repairing, and inspection applications.

Call today for product data sheets, demo disc, or to make arrangements for a free evaluation unit in your facility.

ANCOT CORPORATION

☎[415] 363-0667
fax: (415) 363-0735
Redwood City, California

CIRCLE NO. 66

C&C Computers and Communications



For fast answers, call us at:

USA Tel:1-800-632-3531. TWX:910-379-6985. W. Germany Tel:0211-650302. Telex:8589960. The Netherlands Tel:040-445-845. Telex:51923. Sweden Tel:08-753-6020. Telex:13839. France Tel:1-3946-9617. Telex:699499. Italy Tel:02-6709108. Telex:315355. UK Tel:0908-691133. Telex:826791. Hong Kong Tel:755-9008. Telex:54561. Taiwan Tel:02-719-2377. Telex:22372. Korea Tel:02-551-0450. Fax:02-551-0451. Singapore Tel:4819881. Telex:39726. Australia Tel:03-267-6355. Telex:38343.

Now there's a smarter way to get a single-channel SCC.

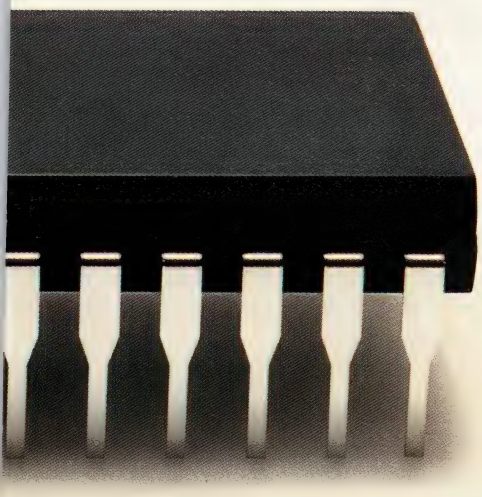
Cut a better deal with NEC's single-channel serial controller.

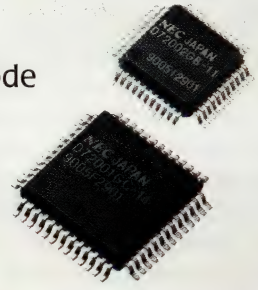
Successful engineers cut waste to create efficient designs. And we think it's pretty wasteful to buy a dual-channel serial communications controller when your system only uses one channel. That's why NEC developed the μPD72002, a single-channel version of our 72001 multi-protocol serial controller.

For single-channel data communications, our 72002 is the cost-efficient choice.

If you need two channels, our 72001 is a proven performer. Both devices offer advanced features, including:

- ☐ Functional superset of the 8530 SCC.
- ☐ SDLC/HDLC/SYNC/ASYNC protocol control.
- ☐ Two baud-rate generators per channel.
- ☐ A pair of transmit data-length registers per channel.
- ☐ Digital phase locked loop per channel.
- ☐ Speeds up to 2.5Mbps
- ☐ 12.5MHz system clock.
- ☐ CMOS with standby mode for reduced power consumption.
- ☐ DIP, PLCC and plastic quad flat packages.





Our 72001/002 lineup gives you unique flexibility in meeting both cost and performance goals. For more information, contact NEC today.

NEC

CIRCLE NO. 67

IC family allows modular design of multiprocessor personal computers

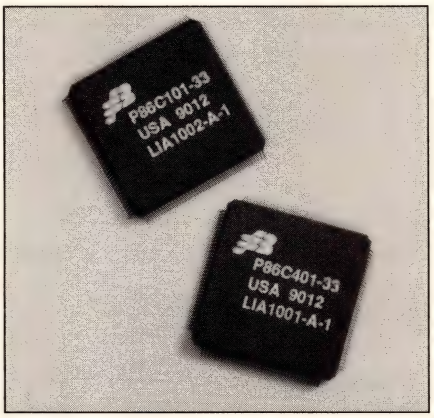
Bucking the trend toward higher integration, this set of ICs allows you to create a personal computer using modular design techniques. In addition to letting you create a family of computer products, the ICs pave the way for multiprocessing.

The ICs support designs based on the advanced chip interconnect (ACI) bus, an open bus standard for modular computer designs. An ACI computer comprises several subsystems linked by the ACI bus. Each subsystem operates independently, using the bus only when data must be transferred. The bus, therefore, is independent of processor speed and is not tied up by I/O operations.

The bus uses nonmultiplexed address and data signals with synchronous timing. The bus address space is 32 bits wide; the data path can be 32 or 64 bits wide. Data transfers across the bus can be pipelined or not and can be single transfers or bursts of as many as 64 bytes. Transfer rates can be as great as 50 MHz.

The bus specification allows both multiprocessor and multiple master configurations, with the various processors sharing main memory and I/O space. Although multiprocessing operating systems are not yet available, all the circuitry needed for multiprocessor arbitration and interprocessor communication is included within the ACI ICs. A computer designed with the ACI ICs, therefore, would be able to take advantage of multiprocessing as soon as software became available.

The initial release of ACI ICs allows you to create a computer with three subsystems: CPU, memory/cache, and I/O bus and peripheral interface. The 16 ICs provide you with several choices within each subsystem, allowing you to develop a wide range of computer products having the same basic design.



As part of a family of 16 ICs for personal-computer design, *these two devices connect a 486-based CPU subsystem to the advanced chip interconnect (ACI) bus. Other members of the family support memory and I/O subsystem functions.*

Within the CPU subsystem, for example, you have a choice between the 25- or 33-MHz 80386DX and the 80486 for your processor. Further, you can choose to have a subsystem with CPU, cache memory, and main memory or just the CPU and cache memory. In the latter case, main memory would reside in a separate subsystem, and the computer could have multiple CPU subsystems.

The memory subsystem ICs allow you to create either a 32- or 64-bit-wide memory with error-correction code. You can use 256k-, 1M-, and 4M-bit fast-page or static-column dynamic RAMs for your memory, operating at speeds from 600 to 100 nsec. The memory can be 1-, 2-, or 4-way interleaved. One subsystem can be as large as 64M bytes, and you can add as many as four memory subsystems to the ACI bus, for a total of 256M bytes.

For your I/O bus and peripheral-interface subsystem, you have three choices: the Industry Standard Architecture (ISA) of the IBM PC/AT, the Extended Industry Standard Architecture (EISA), or the Micro Channel Architecture (MCA) for your I/O. Common to all three is a peripheral-interface controller that handles serial and parallel ports, timers, and interrupt control.

The I/O subsystem ICs translate address and data from the I/O bus format to the ACI bus format. They provide 24 mA of drive current to the I/O bus, allowing industry-standard plug-in cards to operate on the I/O bus. The ICs also include DMA control and registers that hold the data moving between the two buses, to prevent the I/O bus limitations from affecting the ACI bus bandwidth. Address information is likewise buffered.

Because the ACI bus is an open standard, you can create custom ICs that add other subsystems to the ACI bus. For example, you could create a LAN interface or a graphics subsystem that connects directly to the ACI bus, free of the I/O bus bandwidth restrictions.

The open bus standard also implies that third-party vendors will be developing products for the ACI bus. Prices are not excessive—a 25-MHz 386 ISA-based chip set costs $165 and a 486 chip set costs $187.33 (1000). If you want a multiprocessor-ready computer, you can get a 486-based chip set for $400. Additional processor subsystems would then cost $176 with processor and cache memory.

—Richard A Quinnell

S3 Inc, 2933 Bunker Hill Lane, Santa Clara, CA 95054. Phone (408) 986-8144. FAX (408) 986-1457.

Circle No. 734

MEGA MEMORY.

SONY HIGH-DENSITY SRAMS

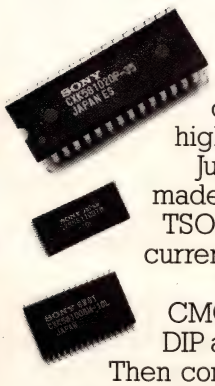
MODEL	CONFIG.	SPEED (ns)	PACKAGING	DATA RETENTION
CXK581000P*	128K x 8	100/120	DIP 600 mil	L, LL
CXK581000M*	128K x 8	100/120	SOP 525 mil	L, LL
CXK581100TM*	128K x 8	100/120	TSOP	L, LL
CXK581100YM*	128K x 8	100/120	TSOP (reverse)	L, LL
CXK581001P	128K x 8	70/85	DIP 600 mil	L
CXK581001M	128K x 8	70/85	SOP 525 mil	L
CXK581020SP	128K x 8	35/45/55	SDIP 400 mil	
CXK581020J	128K x 8	35/45/55	SOJ 400 mil	

*Extended temperature range available.

L = Low power.
LL = Low, low power.

MEGA COMMITMENT.





As you can see, Sony's more committed than ever to meeting your high-density SRAM needs.

Just consider the enhancements we've made in a few short months: TSOP and TSOP-reverse packaging. Low data retention current. And extended temperature range.

All based on our unique 0.8-micron CMOS technology, and available in 32-pin DIP and surface-mount plastic packages.

Then consider our ever-increasing production capabilities. We've just added yet another SRAM facility in Japan. And acquired a large AMD facility in San Antonio, Texas.

So you can really count on us in a crunch.

Need more proof we're serious about your each and every SRAM need?

Call us. We've got more breakthroughs on the way. Well over 100 SRAM products spanning the performance spectrum. And the desire to meet—or exceed—your toughest performance spec.

Sony high-density SRAMS are shipping now, complete with competitive pricing. So call (714) 229-4190 today. Or write Sony Corporation Of America, Component Products Company, 10833 Valley View St., Cypress, CA 90630, Attention: Semiconductor sales. FAX (714) 229-4285.

SONY®

CAE tools address requirements of microwave-circuit designers

Because they operate in the gigahertz frequency range, microwave and millimeter-wave circuits demand CAE tools that can handle the modeling and parasitic complexities whose effects are masked at slower speeds. Microwave Musician software aids designers in laying out these circuits while designing them, a common practice for combating parasitic effects.

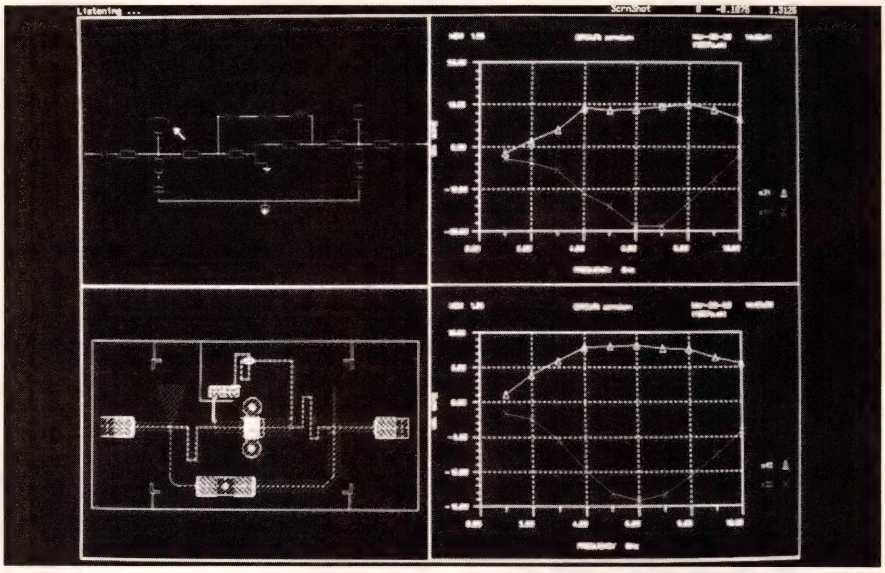
The Microwave Musician combines the vendor's schematic capture, silicon compiler, and layout and verification software tools with interfaces to third-party microwave simulators. Currently available is an interface to Compact Software's linear and nonlinear circuit simulator, Microwave Harmonica. The vendor plans to announce additional interfaces in the third quarter.

The Musician software contains two component libraries whose elements you can use together. The first is a library of ideal microwave components. The second is a GaAs-based foundry-independent library that you can use as a foundation for building your own library. The vendor expects microwave-IC vendors to provide additional foundry-specific libraries for their own parts.

The library-development tools offered in the package let you define the components and control the schematic symbols, simulation models, and layout constraints. The models include transmission lines, discontinuities, bends, and tees, as well as transistors, capacitors, inductors, and resistors.

You can create the physical microwave device using either of two methods. Rule-based silicon compilers can generate the layout for primitive components based on the model libraries and design rules.

Alternatively, if you want to start designing from the layout, you can build all-layer custom primitive cells using the integrated polygon-level layout software. From this physical design, you use an electromagnetic simulator, such as those from EEsof (Westlake Village, CA) and Sonnet Software (Liverpool, NY) to generate the component models for your simulations.



You can create and examine the schematic, *the layout, and simulation results from schematic and layout output simultaneously using the Microwave Musician.*

For circuit analysis, the software allows concurrent control of multiple simulations. When other interfaces are available, you'll be able to run multiple simulators simultaneously under the tool's Motif-based, customizable interface. The software presents outputs in many graphical formats, including Smith and polar charts.

The tool suite includes software to perform electrical- and design-rule checks as well as layout versus schematic checks. The tools offer the flexibility of interactive or batch-mode processing. The verification tools understand microwave design considerations such as coupled lines, distributed elements, discontinuities, and nodellable and unnodellable geometries.

The software runs on Sun-3 and Sun-4 workstations under OS 4.X, on Apollo 3000 and 4000 workstations under SR10, on DEC VAXstations and DECstation 3100s under 3.X, and on HP9000/300s under HP-UX 6.4. The front-end tools include schematic capture, both component libraries, and the framework that maintains the consistent user interface.

The complete Musician CAE suite includes the front-end, layout, and compiler tools; software that combines schematic, layout, and simulation; and software for physical design verification. Available now, the front-end package costs $15,000, and the complete suite costs $30,000. The simulation interfaces sell for $5000.

—Michael C Markowitz

Cadence Design Systems Inc, 555 River Oaks Pkwy, San Jose, CA, 95134. Phone (408) 943-1234. FAX (408) 943-0513.

Circle No. 733

TELECOM DC/DC CONVERTERS

VICOR PROVIDES THE POWER FOR TELECOM APPLICATIONS

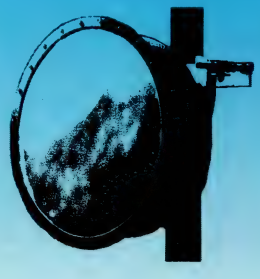
Central Office



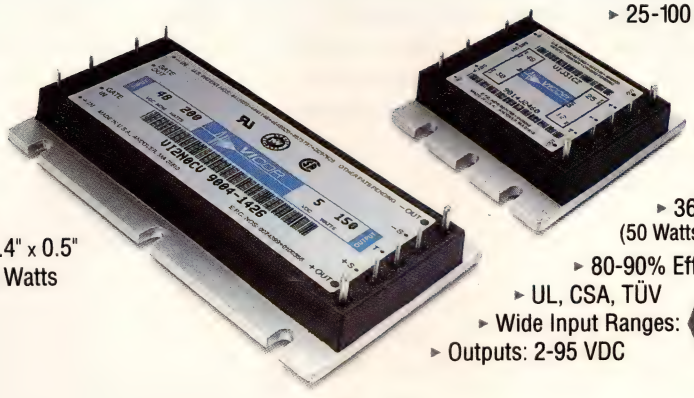
Customer Premises Equipment



Remote Cell Site



VI-J00
- 2.28" x 2.4" x 0.5"
- 25-100 Watts



VI-200
- 4.6" x 2.4" x 0.5"
- 50-200 Watts

Family features
- 36 Watts/in³ (50 Watts/in³–SlimMod™ option)
- 80-90% Efficiency
- UL, CSA, TÜV
- Wide Input Ranges: 36 to 76 VDC, 21 to 56 VDC, 18 to 36 VDC
- Outputs: 2-95 VDC

From remote sites in Alaska and desert sites in Egypt to central offices in Oklahoma, agency approved Vicor converters have consistently demonstrated the ability to meet rigorous demands (Bellcore or British telecom) at competitive prices.

For immediate delivery of converters or for additional information call VICOR EXPRESS today at 1-800-735-6200

Component Solutions For Your Power System

VICOR

Common Stock traded on NASDAQ under "VICR"

3M Now Includes Dispensers with Electrical Tape Orders

Promotion highlights introduction of new MR 93/94 composite insulating tapes

AUSTIN, Tex. – New 3M MR 93/93B and MR 94/94B electrical tapes have a polyester film non-woven laminate construction with rubber thermosetting pressure sensitive adhesive. Both tapes are offered in tan or black, MR 93/93B has a 0.5 mil polyester film base; MR 94/94B has a 1.0 mil polyester film base.



Scotch™ brand tape dispensers being offered with selected 5 case and 20 case electrical tape orders.

Produced by a proprietary 3M manufacturing process, they have greater tack and better solvent resistance. These new MR tapes are also thinner in order to save space without sacrificing insulation values.

These tapes meet Class 130° C temperature specifications per UL Standard 510, UL File No. E17385, Guide OANZ2.

3M is currently conducting a special promotion whereby purchasers of 5 cases of MR 93/93B or 94/94B tape will be given either a P52 or P56 Dispenser. For 20 case purchasers, the M920 Definite Length Dispenser will be awarded. Limit 5 dispensers of each size per customer.

Dispensers help workers get the tape off the roll and onto the job more quickly, according to Gary Long, 3M Tape Marketing Manager.

Special slitting services, just in time delivery, and volume pricing arrangements are also available.

For more information, contact a 3M Electrical Specialties Division representative or authorized distributor or call 1-800-233-3636.

3M Electrical Specialties Division
PO Box 2963
Austin, Texas 78769-2963

3M

CIRCLE NO. 70

PRODUCT UPDATE

Software synthesizes FPGA logic layouts

The PGADesigner family of logic-synthesis tools for field-programmable gate arrays (FPGAs) can synthesize layouts for Xilinx's XC2000 and XC3000 logic cell arrays, Actel's ACT1010 and ACT1020, Altera's Max series, and AMD's Mach 1 and Mach 2 families. These FPGA vendors have certified the tools for their devices. Certain versions of the tools can also automatically partition some or all of your FPGA design over multiple smaller PLDs, such as the 22V10.

You can enter your design in any combination of three methods: schematics with any program that produces an industry-standard EDIF (electronic data interchange format) output file; a waveform editor; or hardware-description languages.

The waveform editor and hardware-description languages are carry-overs from the company's earlier PLD tools. To use the waveform editor, you draw the input and output waveforms for your circuit with a graphics editor. The software then synthesizes a synchronous circuit that accepts the specified inputs and generates the specified outputs.

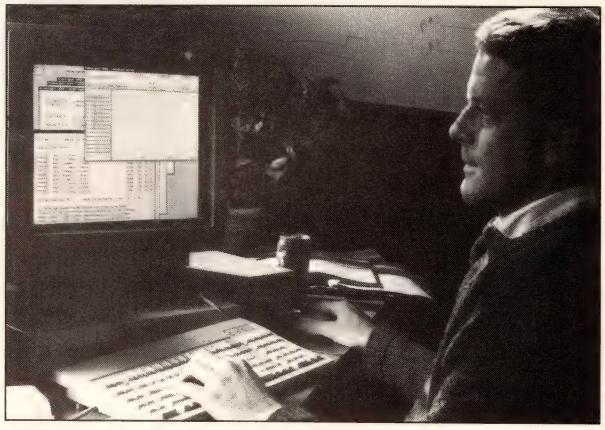
The hardware-description languages let you specify your design with Boolean equations, truth tables, and state machines. The state-machine tool uses a Pascal-like syntax and allows you to embed Boolean equations and truth tables in the arguments of the state-machine program constructs.

In contrast to tools that map your design over precompiled macros, these FPGA tools first perform a device-independent logic synthesis, delivering your design to a particular device vendor's layout program in optimal form. As with the company's earlier PLD tools, you can specify a range of parameters that the tools will use when optimizing and reducing your design.

The tools run on Sun-3 and Sun-4 workstations as well as on 286 and 386 MS-DOS machines. The company offers two configurations: one supports both PLDs and FPGAs, and the other handles FPGAs only. Base prices include routines for one FPGA type, with additional FPGA types optional. Prices range from $2500 for FPGA-only DOS to $14,000 for FPGA and PLD for Sun-4. Xilinx and Actel versions are available now; Altera and AMD will be available in the fourth quarter of 1990.—***Charles H Small***

Minc Inc, 6755 Earl Dr, Suite 200, Colorado Springs, CO 80918. Phone (719) 590-1155. FAX (719) 590-7330.

Circle No. 730

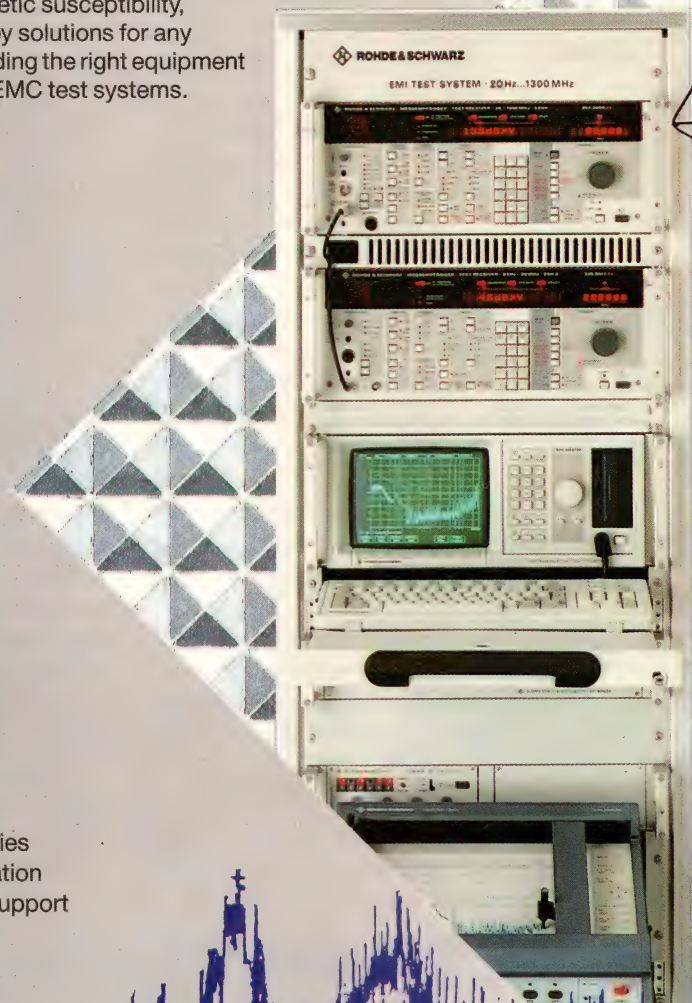


Permitting multiple design-entry methods, *the PGADesigner tools will also compile your design over different FPGAs (field-programmable gate arrays) or PLDs.*

EMC Test Technology
from Rohde & Schwarz

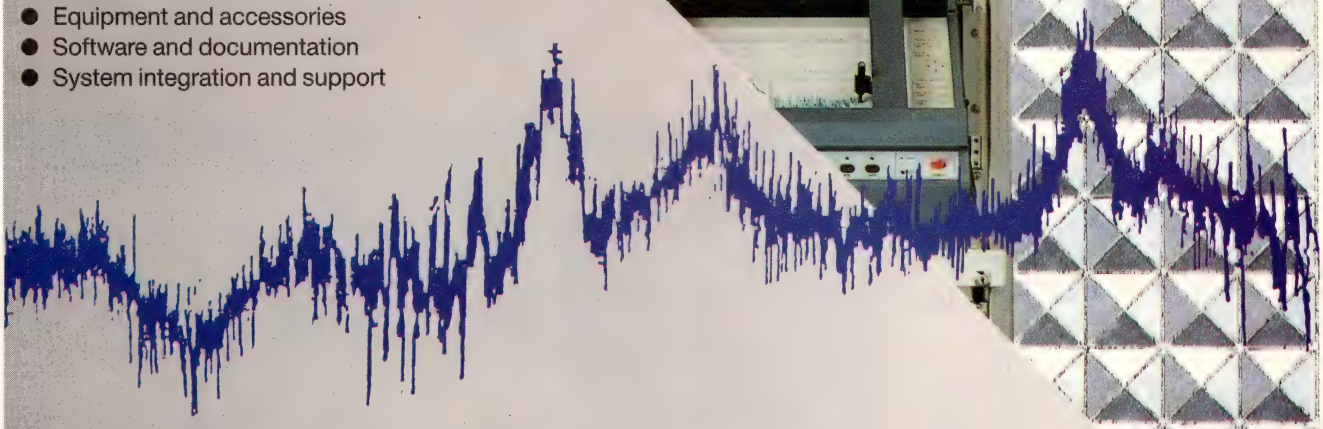
Sizing up EMC

Whether you want to quantify electromagnetic interference or electromagnetic susceptibility, Rohde&Schwarz has turnkey solutions for any problem you may have in finding the right equipment for even the most complex EMC test systems.



EMC Test Technology from a single source

- Advice and planning
- Equipment and accessories
- Software and documentation
- System integration and support



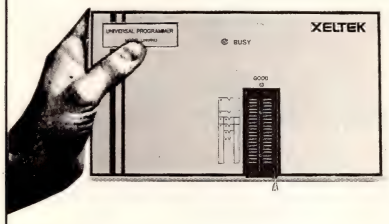
D-8000 München 80
Postfach 80 14 69
Telex 523 703 (rs d)
Telefax (0 89) 41 29-21 64
Tel. internat. +(49 89) 41 29-0

ROHDE&SCHWARZ

An independent concern, founded in 1933.
5000 employees, represented in 80 countries.

$585
(COD, VISA, MC, AMEX)

UNIVERSAL PROGRAMMER



■ PROGRAMS
- E(E)PROMs upto 4MBits & 16Bit wide
- PALs from AMD, MMI, TI, NS, CYPRESS etc.
- 22V10 from AMD, ATMEL, TI, SAMSUNG & CYPRESS.
- EPLDs from ALTERA INTEL, TI.
- GALs from LATTICE, SGS & NS.
- FPLs from SIGNETICS.
- PEELs from ICT, HYUNDAI & GOULD.
- BIPOLAR PROMs.
- SINGLE CHIPs (8748, 8751 & 87C51 series)

■ SUPPORTS
- 32Bit WORDSPLIT with 4 GANG adaptor.
- PALASM2/CUPL/ABEL/TANGO/OrCAD JEDEC files.
- PAL VERIFICATION using TEST VECTOR.
- GAL electronic signature recognition.
- 87C451,63701 X/Y/V & 63705V with adaptor (option)
- Tests ICs (TTL,CMOS)& D/S Memorys ICs with user definable test patterns.

■ Package includes software, programming module, high speed interface card and Cable.

■ OPTIONS
- Socket adaptors for PLCC, LCC, SOIC, and FLAT-PAK ICs.
- 4 Socket adaptor for E(E)PROMs.
- Socket adaptors for micro controllers.

LOGIC PROGRAMMER $395
- PROGRAMS PAL, GAL, PEEL, EPLD
- Pull-down menu driven softwere

E(E)PROM PROGRAMMER
- Programs 16K-1024K EPROM, CMOS.
- 1, 4, 8, 16, Gang programmers.
- High or low byte programming.
- from $150

EPROM ERASER

■ QET-140 ($295)
· Erases any EPROM just. 4 seconds.

■ ET-140 ($95)
· Erases upto 9 EPROMs

■ ET-265 ($285)
· High capacity.
· Erases upto 30EPROMs W/timer.


QET-140

1YEAR WARRANTY & 30 DAYS MONEY BACK GUARANTEE

XELTEK

Call Now 1-800-541-1975(Toll Free Order)
TEL.(408)727-6995 FAX:(408)727-6996

473 Sapena Ct.,Unit 26, Santa Clara CA95054

DSP analysis software graphically depicts results

Running on any IBM-compatible PC, Fourier Perspective III software graphically outputs results of common DSP functions. The software package can operate on data sets as large as 65,520 points loaded from disk or captured at runtime from an A/D converter board.

The DSP software can perform single-dimension FFTs and inverse FFTs. Signal-smoothing functions consist of moving-average filtering and median-window filtering; bandpass filtering is also included. The package contains apodizing and windowing functions used to preprocess signals. You can set the program to perform convolution and deconvolution. The software also features signal correlation functions and arithmetic functions that handle complex conjugates. The program works with single- and double-precision IEEE floating-point numbers or with integers.

The software will run on a system as simple as an IBM PC with two floppy-disk drives, 512k bytes of RAM, and MS-DOS 3.0. Serious users should plan on using an 80286 or 80386 system with a hard-disk drive and a graphics display. A math coprocessor typically increases the speed of arithmetic operations tenfold. A 33-MHz 80386 system with a 25-MHz math coprocessor can do calculations for 504 data points in 180 msec.

Fourier Perspective III includes the company's Data View graphics software, which handles graphics operations. Data View software can drive Hercules monochrome, CGA, EGA, VGA, and super VGA displays. This software also supports more than 50 dot-matrix printers, laser printers, and plotters. You can store graphics outputs in files compatible with Tektronix format, Digital Research's GEM format, encapsulated post script, and HPGL (Hewlett-Packard Graphics Language).

The Fourier Perspective III software package costs $695. The company will sell multiple-use licenses. A number of A/D and image-processing boards are available as options.—***Maury Wright***

Alligator Technologies, Box 9706, Fountain Valley, CA 92708. Phone (714) 850-9984. FAX (714) 850-9987.

Circle No. 735



Graphically displayed DSP functions, *generated by the Fourier Perspective III analysis package, simplify the interpretation of acquired data.*

AT&T.

Nobody makes more connections.



AT&T provides all your end-to-end transmission solutions with our full line of fiber optic, copper cable and connecting components.

If your regular route just isn't getting you there, make a right turn. AT&T has the connections you need.

Like data cable, composite fiber/copper cable and optical cable and fiber. Connecting components like ST® connectors and FDDI jumpers. 110 connecting blocks. Splicing and test equipment. Plus, tactical fiber assemblies for harsh environments.

Everything you need in copper and fiber optics for the transmission of voice, data, image and remote sensing. In both network and component solutions. For present and future needs.

But when you buy even just one AT&T component, you're getting more than just a "part."

You're getting over 100 years of AT&T cable and apparatus manufacturing and development experience. Plus the design expertise of AT&T Bell Laboratories.

So take the route you know will make all your connections. AT&T. Just give us a call at **1 800 372-2447, ext. 585.**

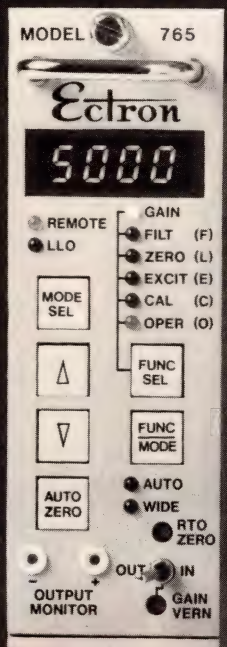
The components of success.

AT&T
Network Systems

CIRCLE NO. 73

IEEE-488 Programmable Transducer Conditioning Amplifier

Completely self-contained excitation, signal conditioning, calibration, amplification and filtering; fully programmable via IEEE-488 or FRONT-PANEL.



GAIN programmable from 0.01 to 10,000

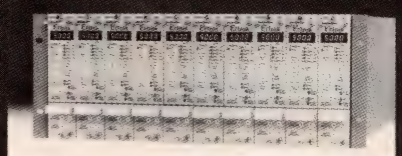
Separate AUTO BALANCE and true AUTOZERO

Front panel access, control and display of all programmable functions



Front-panel plug-in Configuration Card with bridge completion, balance and calibration resistors

19" rack mounting for up to 10 amplifiers includes IEEE-4888 remote control interface.



Ectron CORPORATION

8159 Engineer Road, San Diego, CA 92111
(619) 278-0600 FAX: 619-278-0372

PRODUCT UPDATE

Prototyping system executes control algorithms

Process-control engineers can prototype and verify control algorithms with the ICI-100 hardware/software environment. Although the environment produces runnable C or Ada programs and executes them on its proprietary hardware as an intermediate step, the environment's end product is control diagrams. Software engineers must hew to the control-diagram algorithms to produce the actual software for your application.

To develop and verify control algorithms, you first draw functional diagrams of the algorithm on the system's VAXstation 3100 color screen. You draw the diagrams using structures that are familiar to control engineers: state diagrams, block diagrams, control/data-flow diagrams, and interactive process-animation screens. The environment then automatically translates the diagrams into C or real-time, multitasking Ada programs; compiles them; and downloads them to prototyping hardware for execution.

The prototyping hardware's target controller is a Multibus II board. The board features an 80386 processor and optional 80387 or Weitek 3167 coprocessors. The software can run on multiple processor boards.

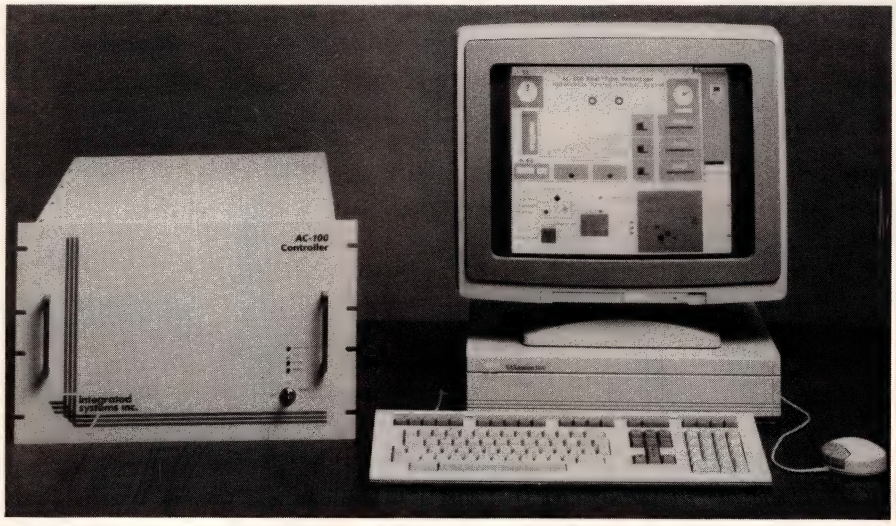
In addition to serving as a functional simulator, the hardware can stand in for your target system if its I/O channels meet your target system's specs. The hardware's standard I/O boards offer 16 analog inputs, 10 analog outputs, 16 digital inputs, 16 digital outputs, eight encoder channels, and a trigger input. Other I/O functions are optional.

The ICI-100 system includes software, VAXstation 3100 (19-in. color screen, VMS operating system, 8M-byte RAM, two 105M-byte discs, tape drive), and prototyping hardware (Multibus II backplane, 80386 board, digital I/O board, analog I/O board, Ethernet) for $135,000.

—Charles H Small

Integrated Systems Inc, 2500 Mission College Blvd, Santa Clara, CA 95054. Phone (408) 980-1500. FAX (408) 980-0400.

Circle No. 731



The ICI-100 prototyping environment *translates conventional process-control diagrams into executable Ada programs and then runs them on its Multibus II hardware.*

It Takes One To Know 1μm.

And, Mitsubishi is the only one who reduced 1μm gate width to a size that's small enough to provide a low, 5μW power dissipation (the lowest you can get), lower operating temperature and small die size. Plus, we're the only supplier to give you performance as fast as 370 picoseconds and four speed/power options: x1, x2, x3, and x4. So, you can optimize your circuit for *both* fast speed *and* low power. By taking advantage of Mitsubishi's smaller cell sizes, you achieve low operating temperature, more-cost effective silicon use

We're The Only One With 5μW And Four Speed/Power Options.

and smaller die size. And, all this means we can help you put your designs in smaller, lower-cost plastic packages and achieve higher reliability. Plus, our selectable output buffer drive and slew rate control help reduce noise and electromagnetic radiation. Mitsubishi offers 70,000 gates (50% utilization); patented* gate isolation structure for faster performance, and extensive packaging options, including plastic QFPs, very-fine-pitch QFPs (VQFPs), PLCCs and APGAs (adaptable pin-grid-arrays). And, of course, we give you 100% burn-in, 100% AC and DC testing, a library of more than 500 cells and design kits for the industry's leading-edge CAE design tools. It takes one solid, proven semiconductor supplier to know 1μm. We're one of the top ten worldwide semiconductor manufacturers, and the world's fifth largest MOS memory manufacturer. We've been producing gate arrays since 1976 and offer production capacities surpassed by none. So, we'll get you through 1μm design, prototype and production *fast* and *right the first time*. Also, keep in mind, a good 1μm will get you to a great 0.8μm! Call the one it takes to know 1μm today at **1-800-624-8999 #178.**

*U.S. Patent No. 4,562,453

MITSUBISHI GATE ARRAYS

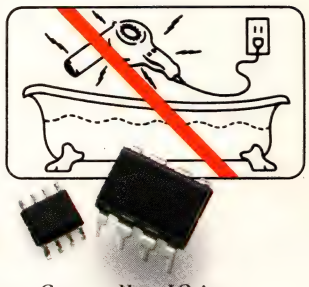
CIRCLE NO. 75

We're Redefining



Defense Technology.





We're taking our linear bipolar military experience and applying it to low cost, high volume applications. Our Ground Fault Interrupter Controller IC is a good example. By preventing electrical shock in consumer products, it gives new meaning to the term *National Defense.*

Raytheon's standard linear ICs and linear arrays are at work in dozens of commercial applications. The reason is simple. They make good business sense.

It's because in developing products our engineers look beyond basic circuit requirements to the demands of your overall system.

We're committed to analog technology. From our design kits and engineering support to our fab and plastic assembly facility, we have the experience it takes to help you develop creative, cost effective solutions.

If you'd like to know how our analog technology can meet your application's needs, call **1-800-722-7074** for our new brochure. Raytheon Company, Semiconductor Division. 350 Ellis St., Mountain View, CA 94039.

CIRCLE NO. 76

Raytheon

Where quality starts with fundamentals

PC-based analog simulation

PC-based analog-simulation software lets you create, develop, and test circuit ideas without switching on your soldering iron. To get the best results from these general-purpose design tools, you must be prepared to delve beneath the graphical user interface and understand some of their inner workings.

Brian Kerridge,
European Editor



You view results during simulation with Microcap III from Spectrum. Transient analysis plots voltage, current, power, energy, and the results of any algebraic formula describing circuit variables.

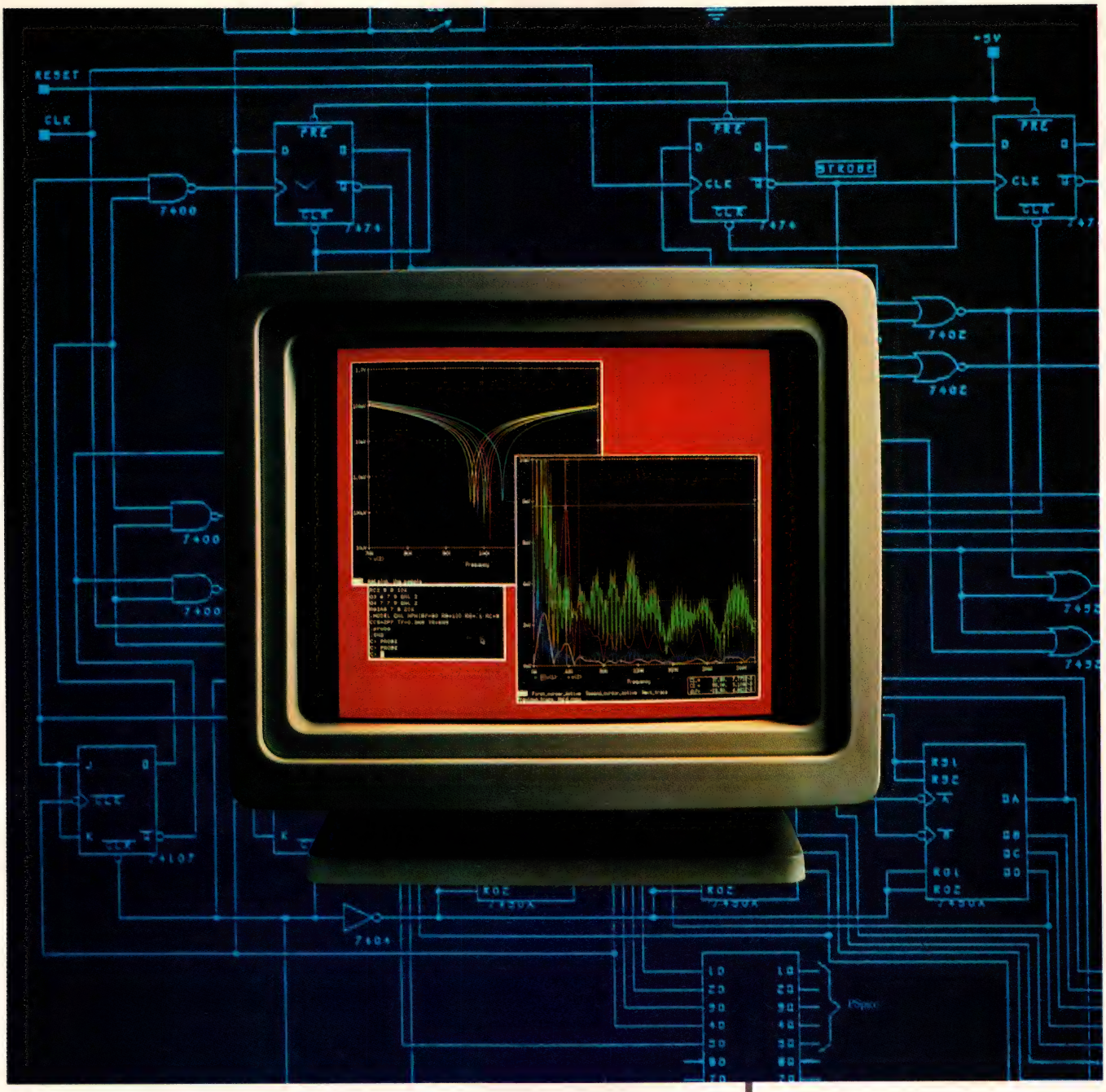
"Give us the tools, and we will finish the job." Fifty years later, analog designers echo Churchill's words to Roosevelt. Their call is for analog-simulation software to use as an everyday bench-level design tool.

Analog simulation isn't new, but in many companies simulation software resides in a central mainframe or workstation resource and is neither readily accessible nor adaptable for work at the design bench. The arrival—intrusion almost—of budget-priced workstation-performance PCs in the laboratory environment changes that that situation. Using stand-alone software costing $195 to $5000, you can set up PC-based analog simulation in your corner of the lab. This setup will relieve you of irksome calculations, so you can channel your effort to innovative aspects of the design.

Engineering managers easily identify the dollar savings of reduced prototype iterations that simulation tools offer, but they often overlook secondary benefits. The human factor is an intangible item and is missing from cost schedules.

The freedom to simulate informally at the bench is much more appealing than joining the queue for a central system—engineers have reclusive tendencies. The opportunity exists to exercise creative ideas on the spot, and at any time engineers can attempt endless "what-ifs" on a design—many more than they would attempt on a hardware prototype. This experimenting consolidates the design and, more important, deepens an engineer's understanding of his or her own creation. John Pickering, director of engineering at Datron-Wavetek (Norwich, UK) and veteran analog designer, says, "Simulation lets you be more imaginative with the design. You can take more risks and test out your imaginative ideas. Circuit design is still all about imagination." Pickering uses PC-based simulation for conceptual work on instrumentation designs.

Johnson Matthey Inc (Stoke-on-Trent, UK) decided upon PC-based simulation to gain insight into its video-filter designs. Design Manager Mike Pepper explains that the



company needed a better understanding of the way its products worked. PC-based simulation led the company to re-examine each filter component and establish precise parameters with which to build simulation models. Pepper regards the single most significant outcome of using simulation as the ability to predict accuracy performance in new designs.

Engineers are not always the most organized people, but even those who are often get bogged down and lose track of what they tried when designing a circuit proves difficult. Using a simulator forces you to work systematically, and each time you try something, the changes and results are safely on record. Documentation is a handy by-product of simulation. The quality may not be sufficient to usurp your central drafting facility, but the printout will be clearer than the scratching on an engineer's note pad.

The end result of using analog simulation is a better design earlier on and a higher-quality final product. When your bench work is done, transporting the design to your cen-

Monte Carlo analysis and Fourier analysis are just two of the tools available to you when you use PC-based analog simulation. (Photo courtesy MicroSim Corp)

Let the PC take care of the mathematical tedium of analog simulation while you concentrate on creative concerns.

tral EDA system can be straightforward with some vendor's packages. Meta-Software's HSpice, EEsof's Academy suite, and MicroSim's PSpice run on a wide range of computers including Sun and HP/Apollo workstations and VAX/VMS and DECstation systems.

Enhancing classic Spice

Most early analog simulation programs emanate from Berkeley Spice (Simulation Program with Integrated Circuit Emphasis), which academics at the University of California at Berkeley developed for academics. The university does not support Spice; therefore, the tool is unsuitable for industry. Developing, enhancing, and commercializing Spice is where vendors apply their ingenuity to devise competing products such as those in **Table 1.**

PC-based analog simulation packages range from those that are dedicated to a single function, such as RLM Research's filter-design software, to Viewlogic's design environment, which encompasses schematic entry, analog and digital simulation, VHDL (VHSIC Hardware Description Language) synthesis, and graphical waveform analysis. Some offerings have a strong application bias. EEsof's software optimizes the simulation of RF and microwave designs; Meta-Software's HSpice best suits ASIC work. Selecting a PC-based analog simulation package is not straight-

Table 1—Representative PC-based analog-simulation software

Manufacturer	Product	Price	Behavioral modeling	Mixed-mode simulation	Monte Carlo analysis	Thermal analysis	Sensitivity analysis	Comments
Deutsch Research	TurboSpice	$995	✓	✓	✓	✓	✓	Real-time simulation results. Thermal analysis accepts different temperature on each component.
EEsof	Libra	$20,000			✓		✓	All packages run under company's Academy design framework, which specializes in RF and microwave simulation.
	Microwave Spice	$12,000				✓	✓	
	Omnisys	$15,000	✓	✓	✓		✓	
Interactive Solutions	Promise	$940				✓		Optimizes any number of component values to meet a target specification for the overall circuit.
Intusoft	ICAP/386	$1081	✓	✓	✓		✓	Comprehensive package. Extensive modeling capability. Detailed support documentation and benchmark test results.
Meta-Software	HSpice	$4000			✓	✓	✓	Can be used for a wide range of applications, from pc boards and ASICs to microwave and electro-optical applications.
MicroSim	PSpice	$2450	✓	✓	✓		✓	Comprehensive package—almost an industry standard.
RLM Research	AFDPlus	$850					✓	Dedicated filter-design software.
Sofcad Electronics	Lincad-PC	$195					✓	Entry-level software, suitable for educational establishments.
Spectrum Software	Micro-Cap III	$1495	✓		✓	✓	✓	Comprehensive package. Results plotted during analysis.
Tatum Labs	ECA-2	$1085			✓	✓	✓	Component library available.
Those Engineers	SpiceAge	$450						Entry-level software, popular with educational establishments.
Viewlogic Systems	AArchitect	$15,000	✓	✓	✓	✓	✓	Top-end design environment system. Runs under company's Workview framework.
Visionics	EE Designer III	$4995	✓	✓		✓		Comprehensive design system. Includes schematic entry, analog and digital simulation, layout, and bill of materials.

forward. Some vendor's brochures are skimpy, although demonstration disks are available to help you. Whichever package you choose, make certain of good applications support, as you are sure to call for help.

Problems with early versions of Spice concern accuracy, nonconvergence (simulation jargon for a useless result), and speed. Model development addresses the accuracy problem. The skill here is determining precisely the parameters to install in the intrinsic Spice models. Some Spice vendors do this work for you so that they can offer a model library of commercially available components. If you're designing analog ASICs or other proprietary components, you'll probably need to perform these parametric measurements yourself before you can construct simulation models.

At Linear Technology (Milpitas, CA), all engineers simulate designs using PC-based PSpice, and constructing in-house models is an essential practice. On the accuracy of simulation results, Bob Dobkin, vice president of engineering, says that if models are good then simulation results are very accurate. However, he adds, "The engineer has to take into account a lot of extraneous detail."

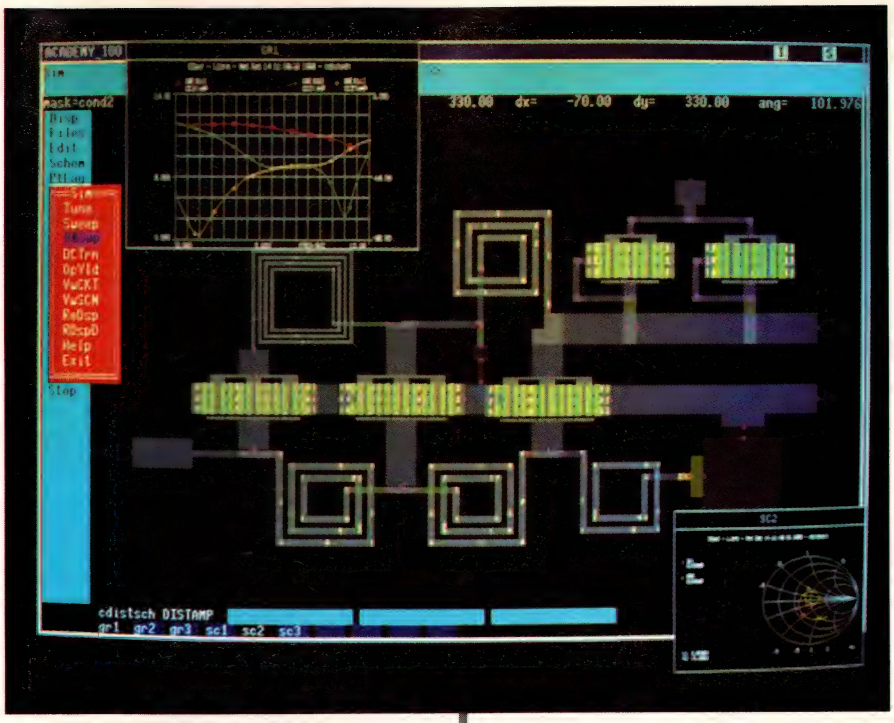
Increasing the chances of convergence is where vendors demonstrate further progress in improving Spice. In most cases, extensive rewrites of traditional Spice reduce your chances of serious nonconvergence, or lots of useless results. Once past the novice stage, users generally agree that the occurrence of nonconverging results diminishes to a tolerable level. Dobkin says, "Convergence was never a real big problem and has become a kind of nonproblem."

Lack of speed is a persistent drawback in PC-based analog-simulation work. Vendors argue that experienced users will trade off accuracy to avoid frustrating time delays. Because simulators are such general-purpose tools (and engineers are general-purpose subjects), vendors find it difficult to recommend the most-suitable PC configuration for their software. Of the software in **Table 1**, some vendors optimize speed with versions to match specific machines. MicroSim offers some guidelines on speed expectations. The company's PSpice runs as fast on a Compaq 386 with an 80387 math coprocessor as it does on a VAX-11/780; an IBM PC/AT is four times slower. Workstations outstrip the performance of the VAX and Compaq machines. PSpice runs 1.5 times faster on a Sun-3/110 and six times faster on a SPARCstation 1.

The number of circuit nodes further affects simulation time. Intusoft publishes the results of its ICAP software running as many as 1000 circuit nodes on a wide range of machines. **Table 2** shows an extract of this information.

The complexity of the models you employ also has a major effect on simulation time. As your experience develops, you can judge if simpler models will suffice for your purposes.

Some rigid conventions apply to



A suite of dedicated software runs under EEsof's Academy design environment. The company's software runs on PCs, Sun and HP/Apollo workstations, and VAX/VMS and DECstation systems.

Selecting a PC-based analog simulation package is not straightforward. Some vendors' brochures are skimpy, although demonstration disks are available to help you.

using these simulators, and an initial encounter with simulation software will cause exasperation. For example, all circuit nodes must have a dc path to ground, and the simple act of entering a capacitor with zero leakage can cause problems. Meta-Software anticipated these early problems and published a detailed application note on this subject.

Schematic-entry options

One decision likely to sway your choice of a simulator is whether you want integrated schematic entry. Schematic entry can be either integral, optional, or nonexistent in a simulation package. The only way to be absolutely sure that a net list and simulator are compatible is to use a simulator with an integrated schematic-entry facility.

If you already have schematic-entry facilities, they will most likely be able to produce a net-list file in standard Berkeley Spice format. Although most Spice vendors glibly acknowledge compatibility with the Spice standard, 100% compatibility may not in fact exist. Both MicroSim and Intusoft, for example, make extensions to Spice net lists to enhance the use of their simulators. Some of these extensions use a syntax that affects the net list. With Intusoft's enhancements, a simulator that expects to see a net list in standard Spice format can pare off the extensions and run the program. MicroSim's PSpice code will not operate in this way.

The differences between Berkeley Spice and Spice rewrites are well defined, and you can easily change one to the other using the text editor that all analog simulation packages include. To make life easier, many schematic-entry programs—even those from competitors—produce net lists in MicroSim's PSpice format.

Net lists usually need only minor edits to drive simulators from different vendors and in different formats. They require additional editing as a design progresses because schematic entry alone often fails to put everything that needs to be in the net list into the net list. Parasitic components, such as stray circuit capacitance and inductance and pc-board-material dielectric-absorption effects, never appear on a schematic but affect a design's overall performance. The absence of parasitics from the simulation design can explain why the results from the first breadboard differ from simulation predictions. You may be tempted to assume that additional simulation is fruitless once your breadboard closes in on design objectives. But with another round of simulation, you can determine parasitic effects that will apply to future designs.

The ease of plucking a component from a library by its type number and inserting it in your circuit simulation can lure you into thinking that you are soldering in the real thing. If you follow this course, the model you use in the simulation will be the default model with the default parameter values that the simulator's vendor has decided

Table 2—Guideline simulation times for different circuit sizes

Circuit			Computer				
Description	Elements	Nodes	80286/80287[3] (6 MHz)	Mac SE/30 (68881[3])	80386/80387[3] (20 MHz)	80486 (25 MHz)	VAX8700
μA709 operational amplifier	41	39	432 sec	83 sec	21 sec	8.5 sec	7 sec
Elliptical filter	118	54	1000 sec	149 sec	44 sec	14 sec	12 sec
Analog correlator	2967	1162	N/A	23,300 sec	6548 sec	1783 sec	2311 sec

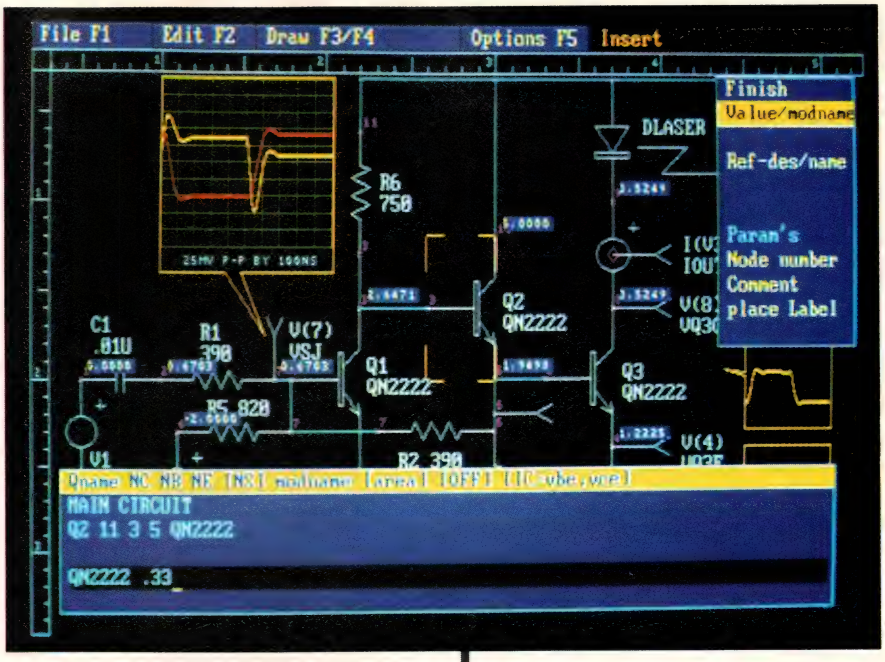
Notes: 1. All simulations carried out for transient analysis.
2. All op amps described in transistor model level.
3. Coprocessor.
4. N/A = not applicable.

(Source: Intusoft)

upon. The vendor's motivation for choosing a particular model is often to demonstrate the software's optimal mix of accuracy and speed. The vendor's difficulty is in devising a simulator with universal appeal that will not perform badly in your special application.

Charles Hymowitz, chief applications engineer at Intusoft (San Pedro, CA), expresses strong views about modeling, "Many novice Spice users do not realize the importance of understanding the Spice models they use or how to handle the modeling pitfalls they will encounter. Many software vendors try to lead these people into the terribly false conclusion that it is OK to just plug in a part model and use it without understanding the model. This very dangerous practice lets vendors take the easy way out. There is no perfect Spice model, and the model listings and their limitations should always be published."

If you are modeling with bipolar-junction transistors and simply choose a model by type number, that model will most likely be based on an Ebers-Moll representation. This representation provides a first-order nonlinear model of the terminal currents and charge-storage effects. For full simulation of the transistor, use a Gummel-Poon transistor model. This model embodies approximately 40 parameters and considers base-width



If a simulator includes schematic-entry facilities, you can eliminate the need to edit the net list before simulating. Intusoft's ICAP includes the SpiceNet schematic-entry program, which the company's PreSpice model library supports. You can create your own symbols to use with standard Spice symbols.

Some background on Spice

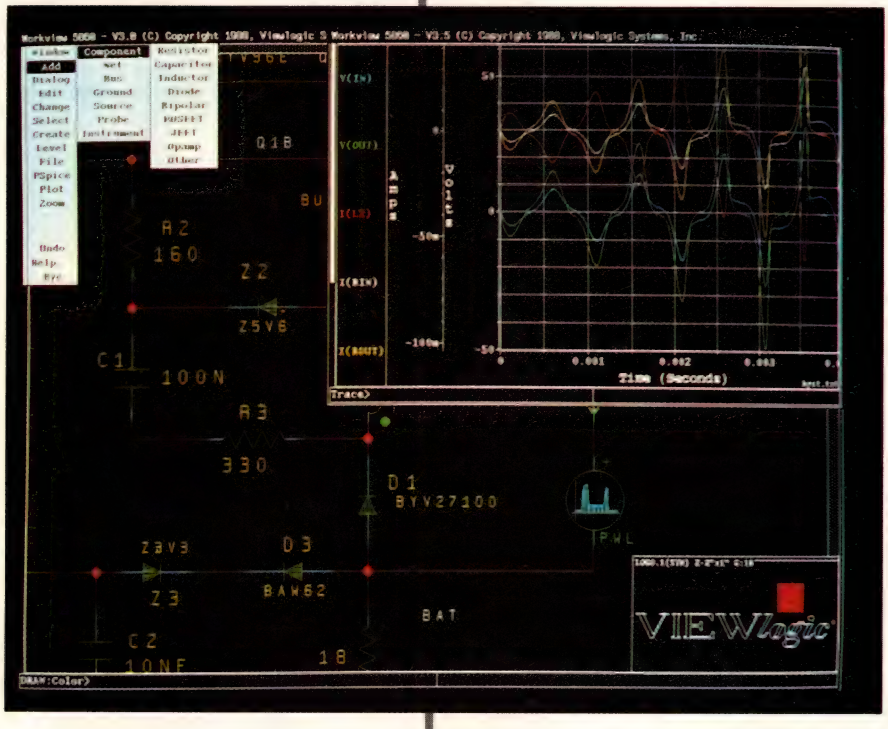
Spice (Simulation Program with Integrated Circuit Emphasis) originated from the University of California at Berkeley and was developed over two decades. Versions of Berkeley Spice up to issue 2G.6 are in Fortran. Berkeley's version 3 is a straight rewrite of 2G.6 in C with additional models.

Vendors are quick to disassociate their software from classic Spice, although most vendors use Berkeley code, usually version 2G.6, as a starting point. MicroSim's software is an enhanced rewrite of 2G.6 in C. Meta-Software's program remains largely in Fortran with C attachments; Deutsch Research based its product on Berkeley 3.

The following types of simulation exist in most vendors software:

- DC quiescent—determines the dc voltage level at all junctions of the circuit.
- DC sensitivity—determines the sensitivity of the circuit's output relative to the dc voltage level at any junction of the circuit.
- DC sweep—determines how the dc voltage level at any junction of the circuit varies with a sweeping input source.
- DC transfer function—determines the small-signal dc gain of the circuit as well as the circuit's input and output resistance.
- AC frequency response—determines the amplitude and phase of signals at all junctions of the circuit as the frequency of an input source is swept.
- AC noise—determines the noise contributions of all circuit components at any junction of the circuit.
- Transient—determines how the signal at any junction responds with time after a change to the circuit's input.
- Fourier analysis—determines the dc and first nine ac components of frequency and phase for a signal at any junction of the circuit.

Understanding Spice models is the key to success with analog simulation.



Design-entry, simulation, and analysis software are integrated in Viewlogic's Viewframe software framework. Other proprietary and third-party tools such as HSpice and PSpice can also run in this framework.

modulation, low I^C β, current-dependent base resistance, and transit time vs I^C. Most software packages provide at least Ebers-Moll and Gummel-Poon models; some packages also have two intermediate-level models. This choice lets you trade off accuracy for simulation speed. For example, the simulation time of the Ebers-Moll model is 20% shorter than that of the Gummel-Poon alternative.

As your circuit becomes more complex, understanding speed-vs-accuracy tradeoffs becomes more critical. If you model an operational amplifier, for example, even if you employ simplified transistor models, the overall simulation time can become unacceptably long. The solution is to introduce a macromodel. Such a model is built from a minimum of Spice primitive elements, but it still simulates overall performance, to a degree.

An op amp in its simplest form is represented by a voltage-controlled source. The macromodel vendors most commonly offer has an input-differential pair of transistors followed by a collection of voltage-controlled sources. The level of complexity you choose for your models determines simulation time over a wide range. For example, if you simulate a typical op amp using full-simulation models for the individual transistors and other components, the results could take as long as 30 minutes. If you accept a simplified model—limiting the transistor models to just the input pair and representing the output drive as a voltage source—your results will arrive in seconds instead of minutes.

When the type number of a component in your design is not in the vendor's library, you may be able to adjust the parameters of interest in the model of a similar device. Resetting a transistor's β, for example, is easy. But often, the parameter value you want to change isn't on the component vendor's data sheet. Intusoft and MicroSim help you around this difficulty by providing generic-model templates that you can tailor to specific component models. Their preprocessing programs translate common data-sheet specifications to Spice model parameter values. In MicroSim's PSpice, graphical feedback presents you with characteristic curves of your model. You can compare these curves with those in the data books to confirm the accuracy of your model parameters.

Component vendors that supply Spice models with their products let you avoid this rigmarole, but few companies are this cordial. One exception is Linear Technology, which just published 40 op-amp macromodels in a PC-compatible disk format **(Ref 1)**. Spice models from other companies include power MOSFETs from Motorola (Phoenix, AZ), op amps from Precision Monolithics (Santa Clara, CA) and Harris (Melbourne, FL), and an assort-

EXPERIENCE THE FUTURE IN CAE/CAD

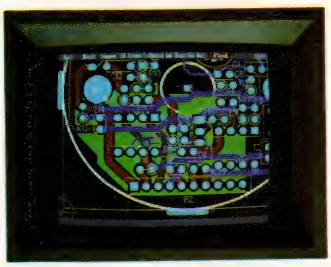
PADS 2000

PADS 2000 is a Personal Computer based Printed Circuit board design system with many advanced features capable of outperforming most Workstation-based CAD systems—*at a fraction of the cost.*

As the most productive PC based board CAD system available today, PADS-2000 can handle even the most complex designs including: double sided surface mount boards, mixed technology boards, high speed designs and layouts exceeding 2000 IC's.

PADS-2000 design functionality includes:

- Over 11,000 parts/32,000 connections
- 1 micron Resolution
- True T-Routing capability
- Intelligent Copper Pour feature leaving isolated tracks and pads
- 0.1° parts/pads rotation
- Extensive Macro capability
- Digital, Analog and Critical Circuit autorouters



- On-line and Batch Design Rule Checking
- Instant track/segment length measurement
- Complete Forward/Backward ECO capability
- Uses 32 bit/386 native code for increased speed and functionality
- Easy-to-learn and Easy-to-use

Call today for a demonstration at your local authorized CAD Software Dealer, or for a NO-COST Evaluation Package.

Ask about our affordable Leasing Plan.

Call Today
Inside MA:
(508) 486-8929
Outside MA:
(800) 255-7814

SEE US AT DAC BOOTH #734

CAD Software, Inc.
119 Russell Street
Littleton, MA 01460

CIRCLE NO. 77

An increasing number of component vendors support their products with Spice models.

ment of devices from Texas Instruments (Dallas, TX). These models are free, but, because they're macromodels, they may not satisfy the real Spice enthusiasts. Some companies, such as Siliconix (Santa Clara, CA), will release "in-house" Spice models—but only to major-account purchasers and in exchange for a nondisclosure agreement.

The design of Spice macromodels is a hot topic among simulation artists (**Refs 2 to 6**). The point is that without thorough knowledge of the models you're designing with, you'll never make full use of simulation. Intusoft's Charles Hymowitz concludes, "The rule is you can never know enough about your Spice models and their characteristics."

If you find the thought of device modeling inspirational, then graduate to behavioral modeling—you'll feel ecstatic. Behavioral modeling lets you use your analog simulator as an analog computer. Instead of piecing together electronic components, you form a network of blocks. You assign a transfer function to each block using a polynomial series or a Laplace transform. The transfer function can be complex; it can involve a series of controlling variables, including time. The possibilities of behavioral modeling will test your imagination because the blocks can represent any physical effect—electrical, mechanical, or chemical. Thus, you can model an entire system from sensor to actuator. Vendors report that their behavioral-modeling tools find use in diverse applications, including the simulation of plumbing systems, both hardware and human.

Parameter sweeping is a Spice

Manufacturers of PC-based analog simulation software

For more information on PC-based analog simulation software packages such as those described in this article, circle the appropriate numbers on the Information Retrieval Service card or use EDN's Express Request service. When you contact any of the following manufacturers directly, please let them know you saw their products in EDN.

Deutsch Research
761 DeSoto Dr
Palo Alto, CA 94303
(415) 327-8677
FAX (415) 327-0325
Circle No. 650

EEsof Inc
5795 Lindero Canyon Rd
Westlake Village, CA 91362
(818) 991-7530
FAX (818) 991-7109
Circle No. 651

Interactive Solutions Ltd
275-281 King St
Hammersmith
London W6 9LZ, UK
(81) 741 5807
FAX (81) 741 5856
Circle No. 652

Intusoft
2525 S Western Ave
Suite 203
San Pedro, CA 90732
(213) 833-0710
FAX (213) 833-9658
Circle No. 653

Meta-Software Inc
1300 White Oaks Rd
Campbell, CA 95008
(408) 371-5100
FAX (408) 346-5953
Circle No. 654

MicroSim Corp
20 Fairbanks
Irvine, CA 92718
(714) 770-3022
FAX (714) 455-0554
Circle No. 655

RLM Research
Box 3630
Boulder, CO 80307
(303) 499-7566
FAX (303) 499-0877
Circle No. 656

Sofcad Electronics Inc
1609 Essex Rd
Columbus, OH 43221
(614) 488-3400
Circle No. 657

Spectrum Software
1021 S Wolfe Rd
Sunnyvale, CA 94086
(408) 738-4387
FAX (408) 738-4702
Circle No. 658

Tatum Labs Inc
3917 Research Park Dr
Suite B-1
Ann Arbor, MI 48108
(313) 663-8810
FAX (313) 663-3640
Circle No. 659

Those Engineers Ltd
106A Fortune Green Rd
West Hamstead
London NW6 1DS, UK
(71) 435 2771
FAX (71) 435 3757
Circle No. 660

Viewlogic Systems Inc
293 Boston Post Rd W
Marlboro, MA 01752
(508) 480-0881
FAX (508) 480-0882
Circle No. 661

Visionics Corp
3032 Bunker Hill Ln
Suite 201
Santa Clara, CA 95054
(800) 553-1177
FAX (408) 492-1380
Circle No. 662

VOTE...

Please also use the Information Retrieval Service card to rate this article (circle one):

High Interest 515 **Medium Interest 516** **Low Interest 517**

Born Better Prepared for Any Game.



286
Industrial Computer

As you face the changing demands of today's industrial environments, Qualogy's 286, 12.5MHz industrial computers will keep you prepared for any game. Our 286 system comes in a rugged rackmount chassis including:

- 10-slot passive backplane
- 200-Watt switching power supply
- Positive airflow cooling
- 1M DRAM, 2 serial/1 parallel port
- Hard disk, 1.2M floppy, 1:1 controller
- EGA card, 101 keyboard, DOS 3.3

The 286, 12.5MHz system comes with a ~~20M~~byte drive, for only:

$3,595

Now with 40 Mbytes.



386
Industrial Computer

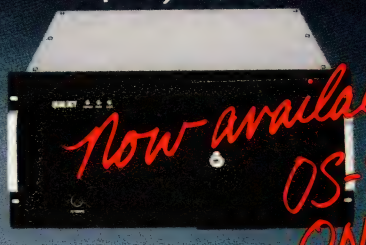
When you need both super speed and ruggedness, Qualogy's 386, 20MHz industrial computers give you the winning edge in the game of your choice. Our 386 system comes in a rugged rackmount chassis including:

Now with 4M.

- 10-slot passive backplane
- 200-Watt switching power supply
- Positive airflow cooling
- ~~1M~~ DRAM, 2 serial/1 parallel port
- Hard disk, 1.2M floppy, 1:1 controller
- EGA card, 101 keyboard, DOS 3.3

The 386, 20MHz system comes with a 40Mbyte drive, for only:

$4,795



Now available: OS-9000 QNX LynxOS

Industrial PC/AT computers and peripherals.

QUALOGY

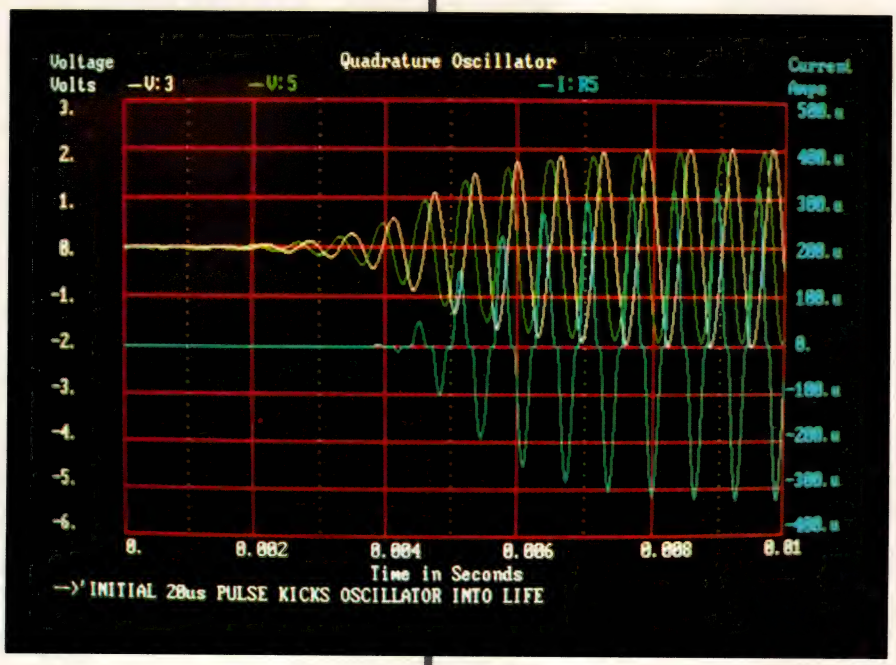
1751 McCarthy Blvd. Milpitas, California 95035 408-434-5200 Fax 408-434-5242 Telex 4993489

Qualogy is a trademark of Qualogy Inc. IBM PC/AT is a trademark of International Business Machines, Inc. Copyright © Qualogy Inc., October 1989. All rights reserved.

CIRCLE NO. 79

Behavioral modeling will test your imagination because the blocks can represent any physical effect—electrical, mechanical, or chemical.

function that gives your design the finishing touch. It lets you study the effect of each model parameter on overall circuit performance. By systematically stepping a parameter through its specified range, you can anticipate the effect of component tolerances when your design reaches production. Vendors describe this technique as sensitivity analysis and often include a variant called worst-case analysis. Worst-case analysis uses parameter sweeping to sequentially determine whether the upper or lower limit of each parameter is the most detrimental to the circuit. The software sets the parameter to this worst-case value before proceeding to the next parameter.



You can simultaneously display waveforms at four points in your circuit with ECA-2 from Tatum Labs. The software can also modulate a component's value by a polynomial function of the voltage between any two nodes.

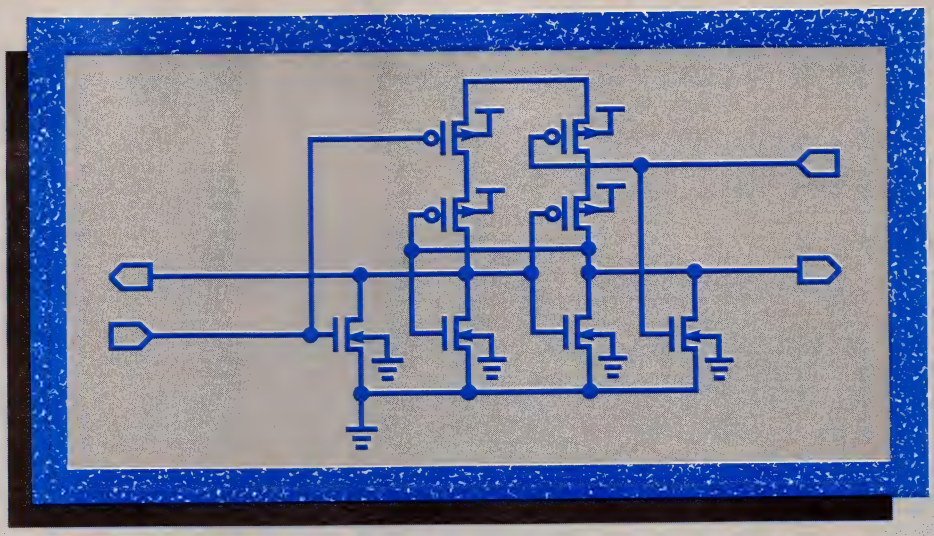
Clearly, worst-case analysis could be time consuming, so vendors have introduced Monte Carlo analysis in an attempt to speed things up. Prior to each Monte Carlo run, all model parameters shift randomly within their assigned range to create a slightly different design. MicroSim and Spectrum Software enhance this feature having their software produce statistical data after each Monte Carlo run. Some users express reservations on the merits of Monte Carlo analysis without a large number of simulation reruns.

Promise from Interactive Solutions lets you use parameter sweeping to optimize a design's component values. You describe a target specification for the circuit and identify any number of component parameters to trim. Simulation proceeds until your circuit reaches the desired level of optimization or until iterations exceed a specified limit. When the optimization halts, the software produces the improved component values. An easy way to enter your target specification is by using a mouse pointer to superimpose the desired circuit response on the simulator's graphical output.

Traditional Spice lets you check a design's operation at different ambient temperatures, and this feature appears in most vendor's offerings. In operation, Spice recalculates internal parameters for all models at the temperature you specify. Some simulators let you define temperature sweeping, which is similar to parameter sweeping, to gain an impression of how your design withstands a movement in common ambient temperature. In practice, of course, different components often operate in localized ambient environments. Deutsch Research's TurboSpice addresses this complexity by letting you assign an individual temperature to each circuit component.

For the foreseeable future, nothing will supplant Spice as the industry standard for analog simulation. Whichever vendor you select, the core product will be similar, and experience migrates from one package to others. Look for a package that offers as much flexibility as possible so you can examine and modify those all-important models. The number of components in the library offers convenience at the out-

HSPICE



HSPICE Provides CAD Framework Independence for Design Engineers who Depend on Frames

CAD Framework Dependence

The most complete set of CAD framework interfaces available. Meta-Software's HSPICE is integrated with every major CAD framework on the market. In fact, over 60% of our customers use frames, relying on HSPICE as a robust simulation engine.

The most advanced MOS, BJT and GaAsFET models and the best track record for convergence and accuracy make HSPICE the ideal choice for circuit design. HSPICE eliminates the weak link in CAD frameworks, and is the true constant in a multiple frame environment.

CAD Framework Independence

CAD framework independence for circuit designers using frames. HSPICE allows engineers to use frames for designing small circuits, then batch the large circuit simulations to remote workstation servers, mainframes or supercomputers.

The result is faster turnaround time and a dramatic reduction in your design time. HSPICE is available on all major platforms, from the PC386 to the Cray.

Your Technology Insurance Policy

The real world solution for your design engineering problems. For over a decade, Meta-Software has been providing HSPICE simulation support and services to circuit designers worldwide. In this fast changing world, HSPICE provides you with the clear advantage of total reliability.

For further information on your HSPICE technology insurance policy, visit us at the Design Automation Conference, (DAC), June 24-27 in Orlando, FL, Booth # 1819, or contact Meta-Software.

META-SOFTWARE

Meta-Software Inc. • 1300 White Oaks Road • Campbell, CA 95008
Tel: (408) 371-5100 • Toll free: (800) 346-5953 • FAX: (408) 371-5638

CIRCLE NO. 78

set, but as your modeling skills develop, you'll want the widest variety of generic models.

If you're an analog circuit designer, sooner or later you'll meet up with Spice. It may as well be sooner, especially if you already have access to a PC. If your engineering manager remains unconvinced, stress the human factors. They alone are worthy of the modest investment. EDN

References

1. Linear Technology Corp, Milpitas, CA 95035, "Library of Spice macromodel op amps," 1989 (on disk).
2. Hageman, Steven C, "Spice model handles linear optocouplers," *EDN*, September 14, 1989, pg 163.
3. Alexander, Mark and Derek F Bowers, "New Spice-compatible op-amp model boosts ac simulation accuracy," *EDN*, February 15, 1990, pg 143.
4. Alexander, Mark and Derek F Bowers, "Op-amp macromodel proves superior in high-frequency regions," *EDN*, March 1, 1990, pg 155.
5. Hageman, Steven C, "Spice models 3-terminal reference," *EDN*, March 15, 1990, pg 180.
6. Filseth, Eric S, Jeff Berwick, and Harold Mann, "Create accurate analog models for better simulations," *EDN*, April 12, 1990, pg 167.

Article Interest Quotient
(Circle One)
High 515 Medium 516 Low 517

WHAT'S COMING IN EDN

EDN Magazine's July 5, 1990, issue will be Part 1 of the semiannual Product Showcase. The issue will feature staff-written reports and product reviews covering software, ICs and semiconductors, power sources, and hardware and interconnect devices. The issue will also feature reviews of computer, component, CAE, and instrument literature. And remember to look for our regular departments.

Thoroughbred

Embeddix SPARC CPUs keep you ahead from start to finish.



You'll be favored to win with the Embeddix MZ 7170 family, the VME processor boards with triple crown features. With the power of SPARC™ and fast-paced Embeddix memory design, the MZ 7170 family lets you run your application in record time. All for a price that keeps you on track.

The MZ 7170 family was bred for demanding applications: a SPARC CPU at up to 25 MHZ (15 MIPS), options for one MB of fast SRAM or up to eight MB of cached DRAM, up to four MB of EPROM, two RS-232 serial ports, mailbox interrupts, real-time clock, and optional 64-bit FPU. SPARC boards from Embeddix are also supported by a complete real-time operating system and Unix™-based development tools.

Race to the finish line with the Embeddix thoroughbreds, the MZ 7170 family.

EMBEDDIX

Embeddix Europe • 63 Buckingham St. • Aylesbury • Bucks. HP20 2NF • United Kingdom
Tel: (44) 296-435214 • FAX: (44) 296-25861

Embeddix is a trademark of Mizar, Inc. • SPARC is a trademark of SPARC International. • Unix is a trademark of AT&T. ©1990, Mizar, Inc.

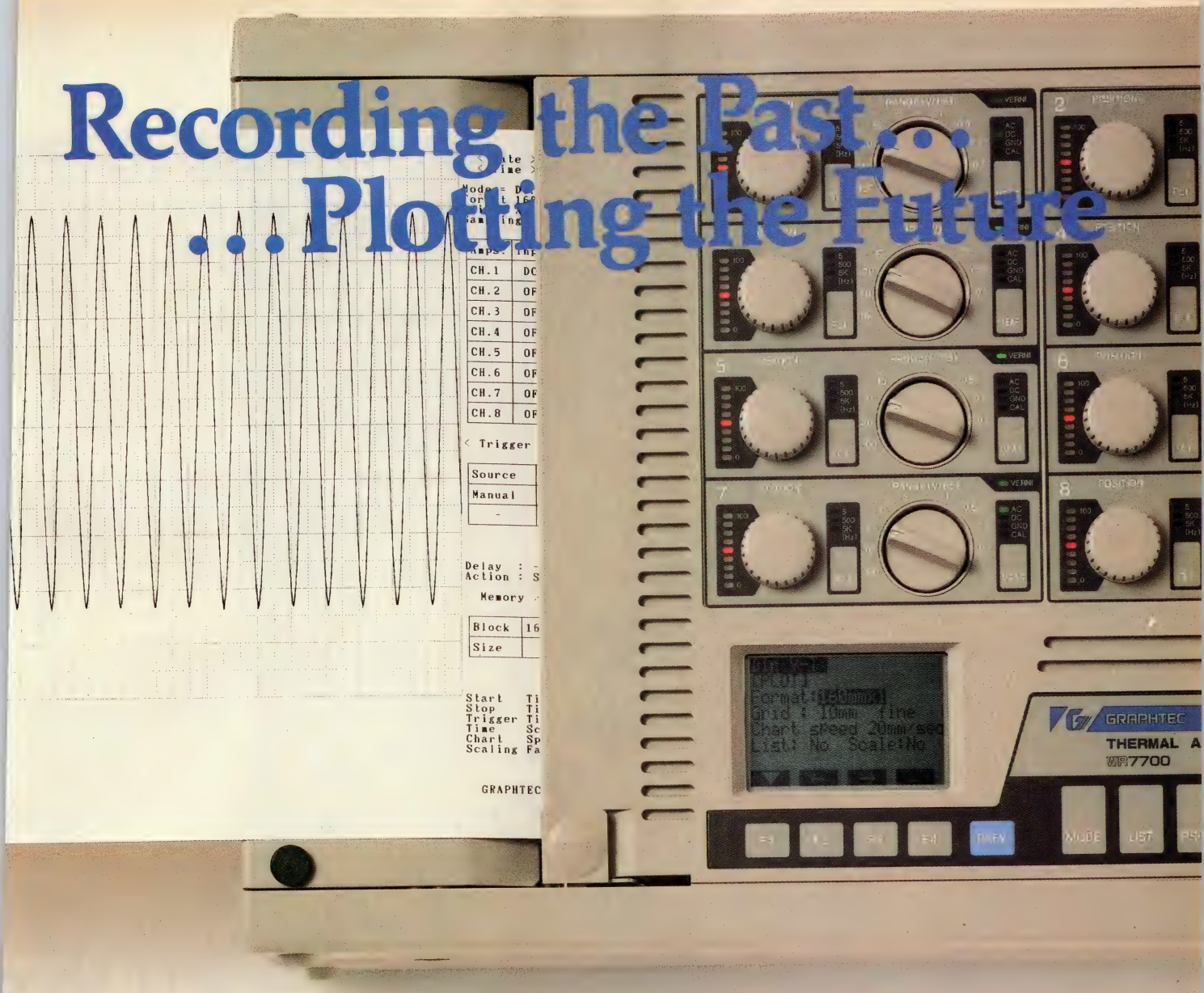
CIRCLE NO. 80

DID YOU KNOW?

EDN serves
electronic engineers and
engineering managers in more than
100 countries worldwide.

EDN

Recording the Past . . . Plotting the Future



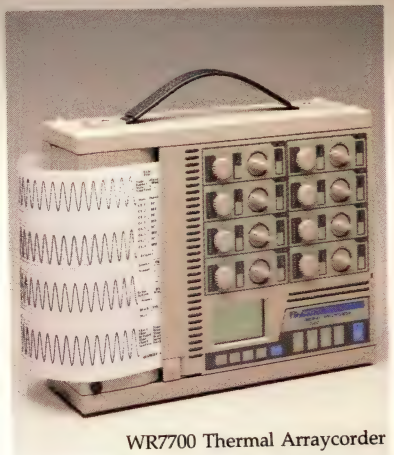
Our reputation precedes us! From 5 subsidiaries and 35 distributors in more than 40 countries worldwide, thousands of customers purchased more in 1989 than ever before. And they were able to choose new products from an ever-expanding array of plotters, penless plotters, digitizers, recorders and supplies.

The Graphtec reputation is one of building products that work well and last a long time. We earned that reputation the hard way, by delivering over 40 years of the best innovation, support, and after-sales service in the industry.

The Graphtec WR7700 Thermal Arraycorder weighs only 14 lbs (6.5 kg), and is highly accurate for both field or lab use. It offers 4 or 8 channel recording at a resolution of 8 dots/mm and a variety of output formats up to 160 mm. The maximum frequency response is 10 kHz.

With portability also comes flexibility: real time or memory recording modes, window triggering, 8 programmable grid patterns, trace expansion, and a 32K memory card for filing of set-up parameters.

The Graphtec WR7700—continuing a reputation for innovation.



WR7700 Thermal Arraycorder

GRAPHTEC

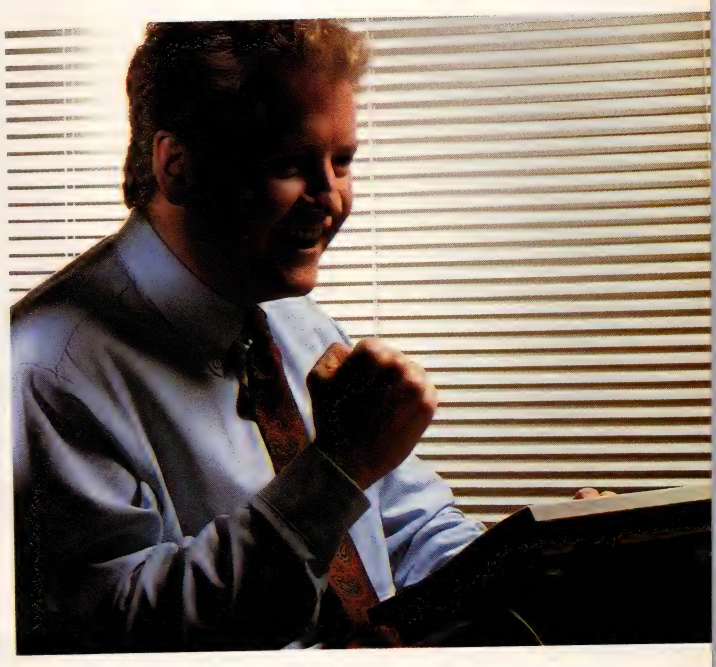
GRAPHTEC CORPORATION Mita 43rd Mori Bldg., 13-16, Mita 3-chome, Minato-ku, Tokyo 108, Japan Tel:(03)453-0511 Fax:(03)453-7187
U.S.A.: Western Graphtec, Inc. Tel:(714) 770-6010 Fax:(714)855-0895
Europe: Graphtec Europe GmbH Tel:(040)511-5059 Fax:(040)511-9155
Australia: Southern Graphtec Pty. Ltd. Tel:(02)748-4888 Fax:(02)748-4882
United Kingdom: Graphtec (UK) Ltd. Tel:(0270)625-115 Fax:(0270)626-733

CIRCLE NO. 81

The Analog Triumph

Cadence Analog Artist™ Design Sys

tem will amaze you.



The first integrated front-to-back analog IC design system.

Cadence Analog Artist™ Design System can dramatically reduce your analog design time. And that's not an idle promise. It's highly interactive, feature-rich, and fully integrated within the Cadence Design Framework™ architecture. Its simulation environment permits quick circuit entry and change. You can interrupt your simulation, view results, check node voltages and currents and then continue without having to restart your simulation. Its physical design capabilities are equally interactive with a design flow interface that lets you control all aspects of your design through simple menu selection. Layout and verification tools provide exceptional power and versatility. Frankly, Cadence Analog Artist Design System will amaze you and reward you with a dramatic reduction in your analog design time. And this is just the beginning. For complete information contact: Cadence Design Systems, Inc., 555 River Oaks Parkway, San Jose, CA 95134. Or call **1-800-283-4080 ext 866.**

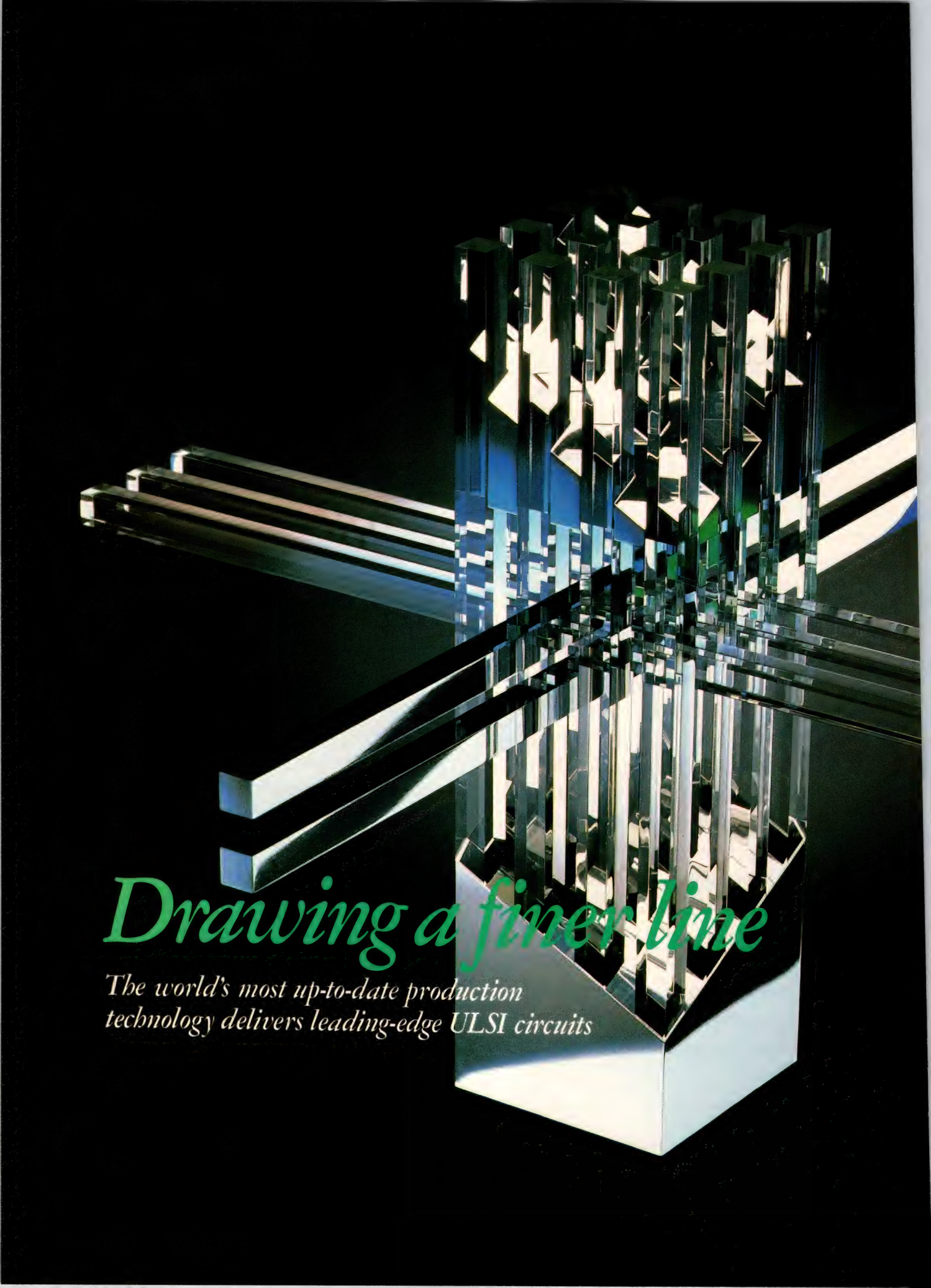
CADENCE

Leadership by Design

CIRCLE NO. 82

SEE US AT DAC BOOTH 3001

Analog Artist and Design Framework are trademarks of Cadence Design Systems, Inc.



Drawing a finer line

The world's most up-to-date production technology delivers leading-edge ULSI circuits

OKI SYSTEM TECHNOLOGIES.

Sub-micron production in full swing, bringing the new age of 4M DRAMs

Oki's Miyagi Plant, benefitting from the latest advances in the company's system technology, has already reached mass production and shipment of 1M-bit memories and has recently begun quantity production of 4M DRAMs. At the Miyagi Plant, broad utilization of ultra-fine process technology and state-of-the-art automation combine to assure the high quality of these products. Oki is already well underway with technological innovation enabling production of 16M-bit memories.

High-level automation with ultra-fine process production

Oki's 0.8μ process technology used in its second-generation 1M- and 4M-bit memories has been integrated into one of the world's most advanced production lines for reliable mass production of over 20,000 6-inch wafers per month.

In 1988 Oki led the world with the first facility dedicated for production of sub-micron devices. Today that lead is being extended with the latest advances in automated manufacturing, such as sophisticated wafer tracking systems for improved quality and production control monitoring.

From the transportation system, driven by linear motors, to individual production equipment in each process machine group, all are computer controlled. To assure products of extremely stable quality, automation and every detail of the production environment are maintained at the world's highest levels.

High performance and packaging flexibility support customers in a wide range of applications

Oki's Advanced System Technologies are dedicated to total customer satisfaction. A comprehensive service system provides flexibility, quality, cost savings and quick turn-around times.



Oki's Miyagi Plant, featuring world-standard process technology and automation.

Oki Electric Industry Co., Ltd.
Electronic Devices Group
Overseas Marketing Group
7-5-25 Nishishinjuku, Shinjuku-ku,
Tokyo 160, Japan
■ Tel: 3-5386-8100 ■ Fax: 3-5386-8110
■ Telex: J27662 OKIDENED

Oki Electric Europe GmbH
Hellersbergstraße. 2, D-4040 Neuss
West Germany
■ Tel: 2101-15960 ■ Fax: 2101-103539
■ Telex: 8517427 OKI D

Oki Semiconductor Group
785 North Mary Avenue, Sunnyvale,
CA 94086, U.S.A.
■ Tel: 408-720-1900 ■ Fax: 408-720-1918
■ Telex: 910-338-0508 OKI SUVL

Oki Electronics (Hong Kong) Ltd.
Suite 1801-4, Tower 1
China, Hong Kong City, 33 Canton Road.,
T.S.T. KLN, Hong Kong
■ Tel: 3-7362336 ■ Fax: 3-7362395
■ Telex: 45999 OKI HK HX

OKI
ELECTRONIC DEVICES

OKI

Oki Electric Industry Co., Ltd.
Tokyo, Japan

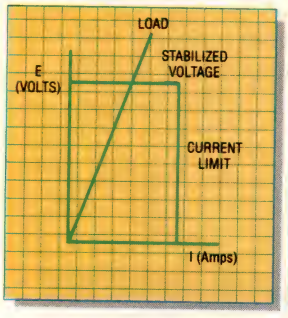
CIRCLE NO. 83

Multi Roles. One actor, many faces...

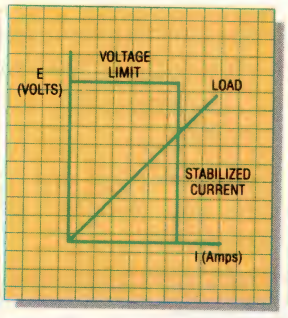


One power supply, many applications.

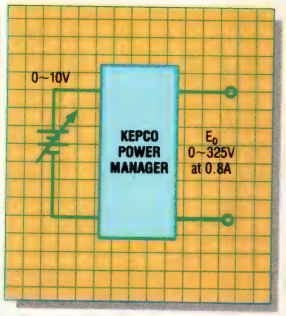
KEPCO'S SERIES ATE VOLTAGE STABILIZERS HAVE MANY ROLES...



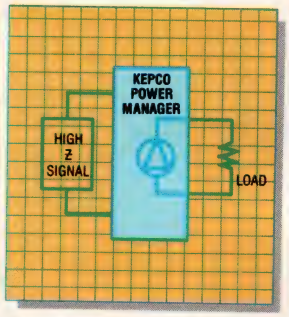
....SUPPLY STABILIZED VOLTAGE
0.001% voltage stabilizer



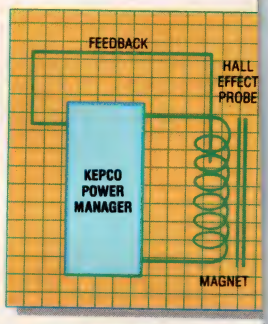
AND CURRENT.
0.005% current stabilizer



THEY'RE PROGRAMMABLE IN VOLTAGE MODE.
A voltage stabilizer controlled by a 0-10V d-c signal



THEY'RE PROGRAMMABLE IN CURRENT MODE.
A current stabilizer controlled by a high impedance source



THEY'LL ACCEPT FEEDBACK.
A magnetic field stabilizer controlled by a Hall-effect sensor



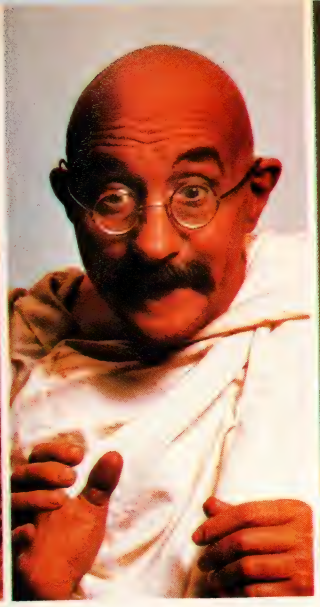
Model ATE 325-0.8M

The actor/model is *Jan Leighton*, whose face has been photographed as everyone from Patton to MacArthur to Lincoln. One face, many roles. More than 3,372 historical notables according to his fact sheet!

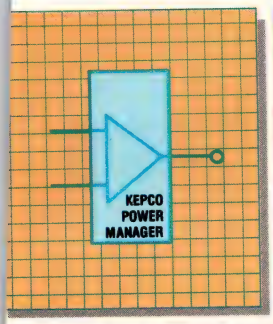
The power supply is Kepco's ATE. While it cannot claim quite so many roles as Jan Leighton, its flexibility will delight you. ATE power supplies are comfortable in roles as voltage sources, current stabilizers, power amplifiers, GPIB listeners and MATE-verified talker-listeners.

ATE are comfortable on your bench, in your systems or installed in your test rack... you can control them with analog signals or digital. You can use their integral uncommitted op amps to scale, sum, integrate or multiply a variety of signal stimuli in servo roles. A versatile piece of test equipment indeed.

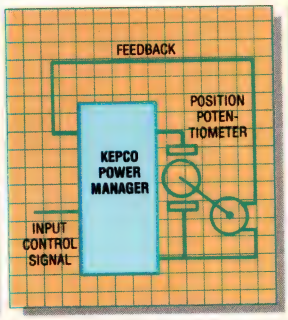




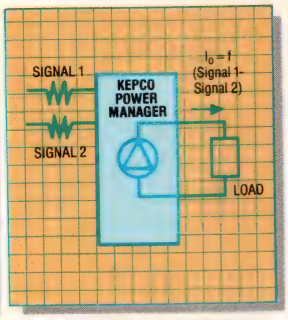




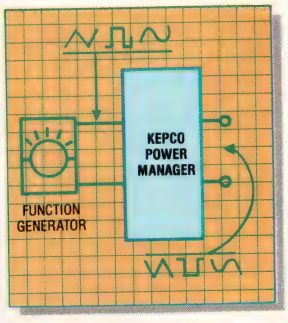
THEY'LL FUNCTION AS AN AMPLIFIER...
A self-powered oversized op-amp



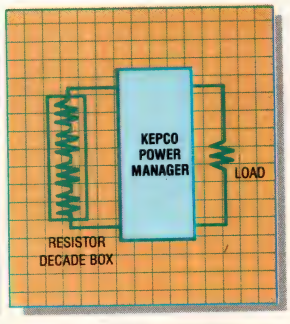
OR CONTROL A MACHINE.
A servo amplifier to drive a positioning motor



ATE CAN SUM INPUT CONTROL SIGNALS
A current stabilizer controlled by the difference between two signals



...BE DRIVEN BY AN ANALOG FUNCTION
A voltage stabilizer controlled by a signal generator



OR INTERFACE TO THE DIGITAL WORLD
A voltage stabilizer controlled by a passive resistance decade box

ATE are made in 5 power ranges, 50 to 1000W (voltage ranges 0-6V to 0-325V) to afford:

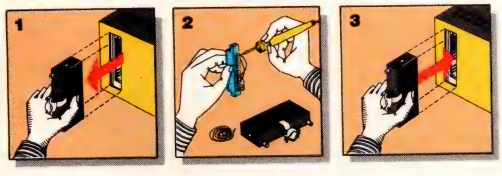
- ☐ High stability (less than 0.0005% source effect, 0.001% load effect).
- ☐ Very low ripple and noise (0.1mV rms, 1mV pp).
- ☐ Rapid recovery (<50μsec).

Most important ... ATE's linear design supports a fast-programming mode which — for your control signals — allows a wide bandwidth response ... 16KHz in our 0-6V, 100 Ampere model, allowing roles ordinary power supplies cannot imagine.

- ☐ *Fast Recovery* current stabilizer
- ☐ *Wide band* power amplifier
- ☐ *Rapid response* to sequenced programs



Like Jan Leighton, Kepco's 41 different ATE models are capable of many roles, limited mainly by your imagination. We'd like to tell you more. Please write or call and request Kepco's new 1990 edition Catalog and Handbook (146-1678).



ATE's unique user port allows you access to the principal control points. A simple 3-step procedure allows you to configure your ATE for whatever role you require.

By appropriate wiring of the mating plug, your ATE easily assumes a variety of roles: voltage/current controller, resistance programmed, voltage programmed, digitally programmed, power amplifier, servo amplifier, integrator.



For your free copy of Kepco's new 120-page Linear Power Supply Catalog (#146-1678), call/fax/write to Dept. LLT-12,
Kepco, Inc., 131-38 Sanford Avenue, Flushing, NY 11352 USA • (718) 461-7000 • FAX (718) 767-1102 • Easylink (TWX): 710-582-2631

CIRCLE NO. 84

KEPCO
THE POWER SUPPLIER™

WORLD CLASS



Condor's International linear power supplies — certified to UL544.

Condor's *International Series II* D.C. power supplies virtually eliminate primary-secondary shorting because each coil uses a separate bobbin surrounded by two layers of glass-impregnated plastic, giving complete mechanical and electrical isolation.

The best low-noise 723 regulator chips are used throughout the line, together with proven, reliable semiconductors. TO3-cased pass elements are hermetically sealed, and the latest high-density, high-ripple current rating capacitors from proven, high-quality vendors ensure long life and reliability.

International Series II features:

- 7 power levels — 3 to 150W
- 70 models (single, dual & triple output)
- OVP on all 5V outputs
- Meets EMI per FCC/VDE B (most units)
- Hermetically sealed power transistors
- MTBF 200,000+ hours per Mil Hndbk 217D
- 2-hour burn-in with cycling
- Full 3-year warranty
- 5th-generation design by Tom Ingman — most copied designer in the power supply industry

Sixty-five *International Series II* models are approved to UL478/1012; CSA C22.2 and TUV certified to VDE 0806 and IEC 435, 1 & 2. Twenty-six models are also approved to UL544. Call us today and put Condor's world-class power supplies to work for you!

Send for our free catalog!



250 power supplies!
Switchers and linears!
Open frame and enclosed!
Custom capability!

CONDOR INC.
DC POWER SUPPLIES

2311 Statham Parkway, Oxnard, CA 93030
(805) 486-4565 • TWX: 910-333-0681
FAX: (805) 487-8911
CALL TOLL-FREE: 1-800-235-5929 (outside CA)

Isolation barrier precisely passes transducer signals

Through the judicious use of isolation amplifiers that incorporate transformer coupling, you can design circuits that condition and amplify low-level transducer signals. Such circuits can precisely measure thermocouple, resistance-temperature-detector and strain-gauge outputs while providing common-mode isolation in harsh environments.

Jeffrey A Greenwald, *Analog Devices Inc, Industrial Products Div*

Isolation amplifiers protect data-acquisition components from potentially destructive voltages present at remote transducers. These amplifiers are also useful when you need to amplify low-level signals in multichannel applications. They can also eliminate measurement errors caused by ground loops. Amplifiers with internal transformers reduce circuit costs by eliminating the need for an additional isolated power supply. And in many cases it's possible to connect a transducer to an isolation amplifier with only a few external components.

The transducers that you'll most often encounter include thermocouples, resistance temperature detectors (RTDs), pressure sensors and strain gauges. These sensors' outputs usually require high amplification. The sensors may also require some sort of external excitation, and you may have to perform filtering or other signal conditioning to yield a useful signal. In some cases, you'll have to offset the sensor's output to place it into the proper signal range for the data-acquisition hardware. You can perform all of these functions with rather simple circuits and precise isolation amplifiers.

The isolation amplifiers you use in these circuits must have high enough breakdown potential to withstand ground faults and thus prevent system destruction. In many applications, you may be called upon to mount pressure transducers and strain gauges on metallic pipes and objects that are at different electric potentials than those of your data-acquisition system. High isolation comes in handy to break ground loops, to reduce noise, or to otherwise allow you to measure strain safely in the presence of several hundred volts.

The isolation amplifier needs to be able to respond to out of range transients that may overload pressure transducers. The AD208, for example, recovers from 5V input transients at a gain of 1000 in 5 msec without damage. Overload often happens when a valve closes, restricting the flow of fluid in a pipe. Since pressure is proportional to force and inversely proportional to cross-sectional area, the pressure rapidly rises to several times the full-scale pressure. This effect is called the water-hammer effect. The same condition is occurring when your pipes make a banging noise after you have shut off the water in the sink.

Possibly the most common transducer that you'll use isolation amplifiers with is a thermocouple. Thermocouples are low-cost sensors, and can measure temperatures over a wide range. **Table 1** lists some common types and their ranges. Thermocouples comprise two

Isolation amplifiers protect data-acquisition components from potentially destructive voltages present at remote transducers.

dissimilar metals. A phenomenon called the Seebeck effect generates a temperature-dependent microvolt signal when the two dissimilar metals join to form a closed-loop circuit.

Although thermocouples are inexpensive, they have one major disadvantage. In addition to the desirable thermocouple effect that you want to measure, undesirable thermocouple effects occur when you attach the thermocouple to the outside world, typically in the form of copper wire. If the thermocouple material is not also copper—it typically is not—additional thermocouple effects known as cold-junction errors occur.

Table 1—Common thermocouples and their characteristics

Thermocouple type	Maximum temperature range at 5V output (°C)	Maximum V_{IN} (mV)	Isolation amplifier's gain setting (V/V)	Suggested resistor values with reference to Fig 2		
				R_F (kΩ)	R_{TRIM} (kΩ)	R_Z (MΩ)
E	900	68.783	72.69	6.98	0.5	2
J	750	42.283	118.25	11.5	1	2
K	1250	50.633	98.75	9.53	1	2
R	1450	16.741	298.6	28.7	2	2
S	1450	14.973	333.9	32.4	2	2
T	350	17.816	280.6	27.4	2	2

For example, the two measurement terminals of a J-type thermocouple consist of iron (Fe) and constantan (Con) contacts. (Constantan is a nickel-copper alloy.) When you attach each side of the thermocouple to copper wire, two different metals join—iron and copper on one end and constantan and copper on the other—to create thermally induced voltages whose values are a function of ambient temperature. The induced voltages at the constantan-copper and iron-copper cold junctions are opposite in polarity to the Seebeck voltage created by the thermocouple.

You can model the two cold junctions as two voltage sources in series with the thermocouple (**Fig 1**). While the thermocouple is sensing temperature at a specific physical location, these cold junctions are functions of the ambient environment. The voltage at the measurement terminal, $V_M(T)$, is the difference between the voltage at the thermocouple and the sum of the induced voltages, as follows:

$$V_M(T) = V_{Fe\text{-}Con(sensor)} - V_{Cu\text{-}Con(ambient)} - V_{Fe\text{-}Cu(ambient)}.$$

Because the two cold junctions have a back-to-back, copper-to-copper connection, you can combine them in a single iron-constantan voltage source. You can then rewrite the voltage at the measurement terminal:

$$V_M(T) = V_{Fe\text{-}Con(sensor)} - V_{Fe\text{-}Con(ambient)}.$$

Canceling this cold-junction effect requires an opposing voltage in series with the thermocouple. This offsetting voltage should generate zero volts at zero degrees C and have a positive temperature slope equal to the thermocouple type you're using. In effect, you need a temperature sensor that measures the cold-junction ambient temperature and produces an offsetting voltage.

One method to measure and compensate for the cold-junction is to use a monolithic cold-junction compensator in series with the thermocouple (**Fig 2**). IC_1 generates a temperature-dependent output of 10 mV/°C. An internal laser-trimmed resistor network scales this signal to provide the correct slopes for most commonly used thermocouple types. You can access the scaled compensation voltage on one of four taps for various standard thermocouples: 60.9 μV/°C (E-type), 51.7 μV/°C (J-type), 40.6 μV/°C (K-type), and 6 μV/°C (R- and S-type).

The isolated ±8V dc supply at pins 5 and 6 of the isolation amp can supply as much as ±5 mA to the cold-junction compensator. However, because IC_1 only draws a maximum of 150 μA, there is sufficient power left over if you need to add more circuitry, such as an

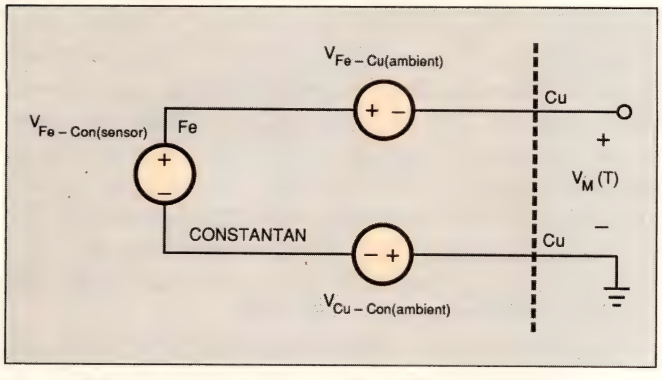


Fig 1—When you connect the two ends of a thermocouple *to a dissimilar metal such as copper, you generate unwanted thermocouple effects called cold junctions. Voltage sources in series with the thermocouple's voltage model the effects of these junctions.*

input filter. In turn, the transformer-coupled isolation amplifier obtains its power from the power-clock driver, IC_3. The clock driver produces a 25-kHz, $15V_{p\text{-}p}$ square wave, which can drive up to 16 fully loaded isolation amplifiers.

You obtain the maximum sensitivity from the thermocouple circuit by amplifying the low-level input signal to the isolation amp's full-scale output range. The following equation yields the necessary gain from a few known values: the output voltage span of the thermocouple that corresponds to the thermocouple's temperature extremes ($V_{TC\text{-}HI} - V_{TC\text{-}LO}$); and the input-voltage requirements of your data-acquisition electronics, $V_{HI} - V_{LO}$.

$$\text{Gain} = (R_F/R_I + 1)$$

$$= (V_{HI} - V_{LO})/(V_{TC\text{-}HI} - V_{TC\text{-}LO}).$$

From the values in the **table**, you can see that a J-type thermocouple has a maximum temperature of 750°C, corresponding to a maximum output of 42.283 mV. Thus, the gain required to amplify the 0- to 42.283-mV signal to a 0 to 5V output span is (5 − 0V)/(42.283 mV − 0 mV), or 118.25.

You can determine the optimal feedback resistor value, R_F, by first setting R_I to 100Ω, and then solving for R_F using the equation $R_F = (\text{Gain} - 1)R_I$, which yields $R_F = 117.25 \times 100$. Note that in **Fig 2**, R_F is the sum of R_F' and R_{TRIM}. To obtain a bipolar adjustment range of ±5% for the gain, choose $R_F' = 0.95R_F$, and $R_{TRIM} = 0.1R_F$.

Similarly, you can use R_Z to set the offset adjustment range. The following equation relates this resistance to the gain, feedback-resistor value, isolation voltage, V_{ISO}, and two offset voltage values. One of these offset values, $V_{OS\text{-}RTI}$, is the referred-to-input offset; the other, $V_{OS\text{-}RTO}$, is the referred-to-output offset.

$$R_Z = V_{ISO}R_F/(V_{OS\text{-}RTO} + (\text{Gain} \times V_{OS\text{-}RTI}).$$

The AD208 isolation amplifier, for example, typically has a V_{ISO} of 8V, a $V_{OS\text{-}RTO}$ of 15 mV max, and a $V_{OS\text{-}RTI}$ of 250 μV max. Using these values and those for the gain and R_F, you can solve for $R_Z \approx 2$ MΩ.

Perform calibration first

For the circuit to achieve maximum accuracy, you'll need to calibrate the circuit in **Fig 2** to minimize offset and gain errors. You can adjust the offset by first shorting pin 1 of IC_2 to pin 2, the Input Common. (Or you can insert the thermocouple in an ice-point refer-

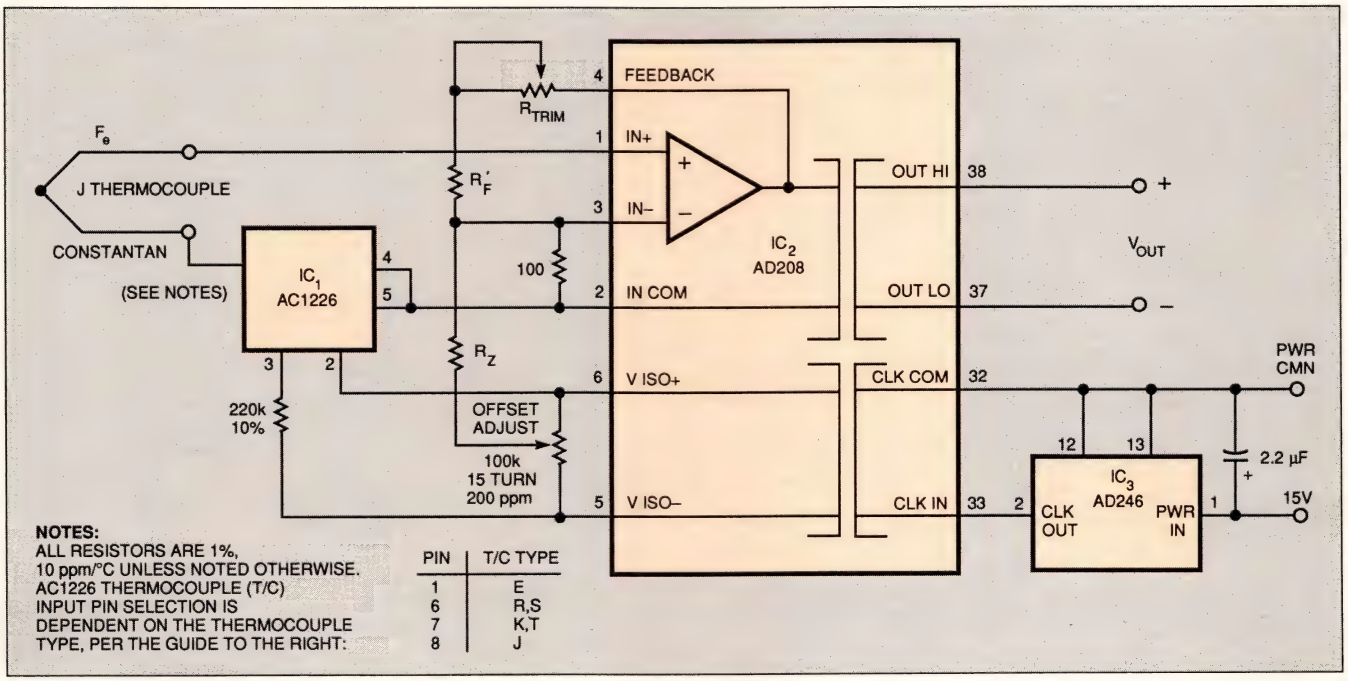


Fig 2—To compensate for cold-junction effects, *this circuit inserts temperature-dependent compensation, generated by IC_1, between the thermocouple and an isolation amplifier.*

A thermocouple relies on the Seebeck effect to generate a temperature-dependent microvolt signal when two dissimilar metals join to form a closed-loop circuit.

ence—a 0°C environment.) Then, adjust the offset potentiometer until the amplifier's output measures 0V. You can calibrate the gain by applying the full-scale thermocouple voltage (42.283 mV for a J-type thermocouple) to the input of IC_2. Then adjust the gain-trim potentiometer until the dc signal at the output of the isolator is 5V. Because the offset and gain may interact with one another, you may have to recalibrate for zero offset following the gain adjustment.

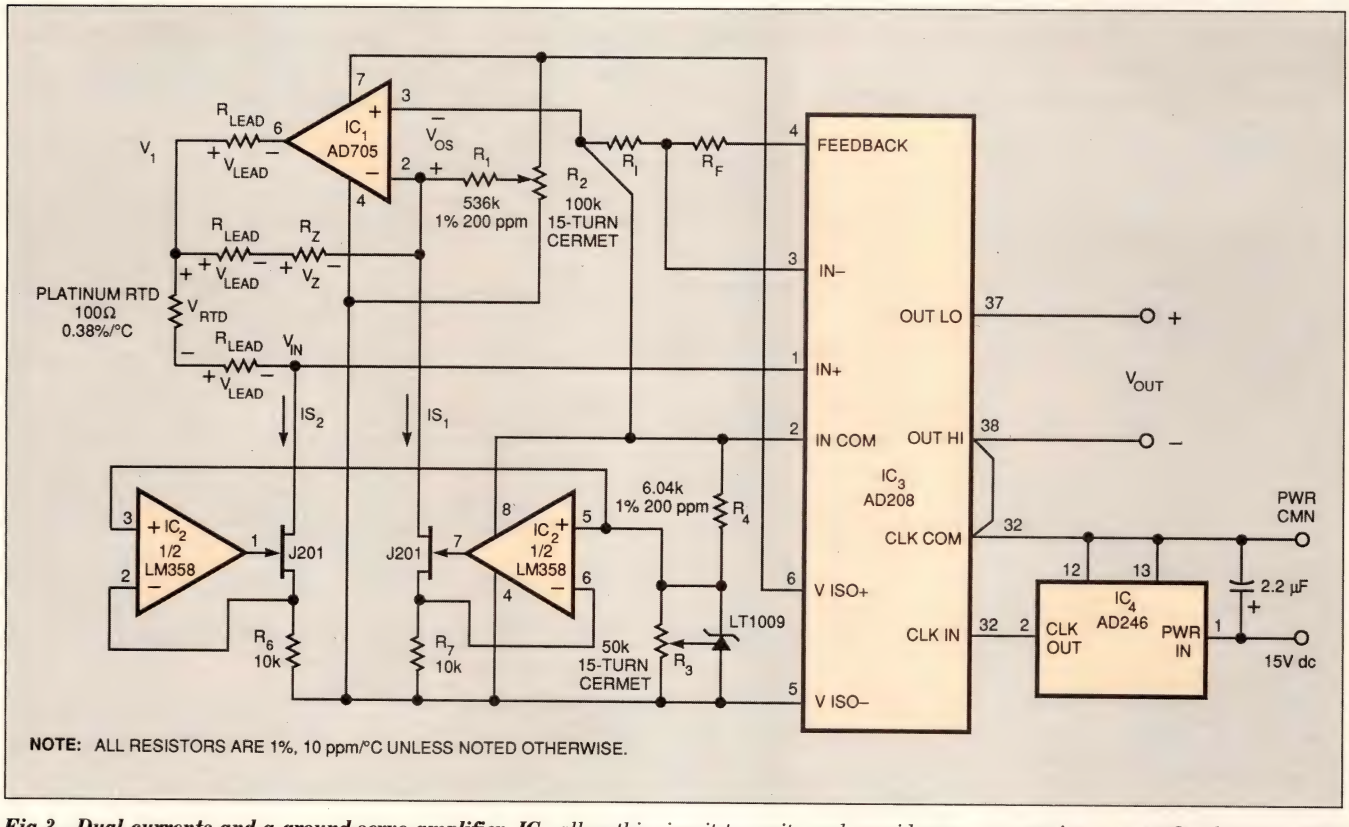
After removing the calibration source, the cold-junction compensator should cause no more than ±2°C of residual error. The temperature stability of the circuit in **Fig 2** (referred to output) is 212.2 μV/°C, yielding a sensitivity to ambient temperature of 0.032 μC/°C. Gain drift is 321 μV/°C, delivering a sensitivity to ambient temperature of 0.048 μC/°C.

Measure temperature more precisely

RTDs offer better stability and linearity than thermocouples, but are limited to temperatures below 850°C. The most common RTDs are made of platinum, because platinum is highly stable at elevated temperatures. Platinum RTDs typically have a 100Ω resistance and a temperature coefficient of +0.385%/°C at 0°C (European DIN Standard 43 760).

Because the RTD's resistance is the temperature-dependent parameter, the signal-conditioning circuit must supply a current to excite the sensor and then measure the voltage drop across the RTD. The circuit must apply relatively low excitation currents to avoid self-heating errors. As a result of the low excitation current and the low sensitivity of the RTDs, you'll need to employ a low-drift, high-gain amplifier to handle the RTD's millivolt output signal. Finally, to obtain the high-measurement accuracy that is possible with RTDs, you need to eliminate any initial offset voltage at the reference temperature, usually 0°C. You'll also need to reduce errors created by lead resistance in the wire that connects the RTD to the measurement electronics.

Fig 3's circuit is one way to achieve these goals. This measurement circuit combines excitation-current sources, lead-wire compensation and amplification for a 100Ω RTD. The LT1009, a 2.5V reference, amplifier



NOTE: ALL RESISTORS ARE 1%, 10 ppm/°C UNLESS NOTED OTHERWISE.

Fig 3—Dual currents and a ground-servo amplifier, IC_1, *allow this circuit to excite and provide zero suppression to a 100Ω, platinum RTD over a 0 to 500°C range.*

IC_1, dual LM358 amplifiers, IC_2, and a pair of low Vgs_{off} n-channel JFETs such as the J201 compose two low-power current sources. One current source, IS_2, excites the RTD. The other source, IS_1, supplies current to offset the RTD such that the voltage at the isolation amplifier's input is zero at 0°C. This zero-suppression technique saves you from having to reduce the gain sensitivity of the RTD circuit to keep the signal within the operating range of the isolation amplifier.

IS_2 excites the RTD with a low current, 250 μA, to minimize self-heating. By adjusting the trimming potentiometer, R_3, you can change the excitation current's range by as much as ±5%. The circuit implements zero suppression using a simple ground-servo amplifier comprising IC_1 and R_Z. (R_Z equals the RTD's 100Ω value at 0°C). The ground-servo amplifier provides an effective means of providing zero suppression without having to use an expensive differential amplifier. It also compensates for the finite lead resistance by remotely sensing the voltage at the RTD.

The current, IS_1, develops a voltage, V_1, equal to

$$V_1 = V_{OS} + V_Z + V_{Lead},$$

where V_{OS} is IC_1's offset voltage.

IS_2 in turn generates the voltage, V_{IN}, seen by IC_3's input amplifier. The value of V_{IN} equals

$$V_{IN} = V_1 - V_{RTD} - V_{Lead}.$$

Substituting the previous equation for V_1 in this equation for V_{IN} yields

$$V_{IN} = V_{OS} + V_Z - V_{RTD}.$$

The trimming potentiometer, R_2, connected between $\pm V_{ISO}$ and the large injection resistor, R_1, nulls any residual offset. To minimize errors created by offset drift in IC_1, choose a low-power, low-offset, and low-drift amplifier for this function.

The sensitivity of a 100Ω platinum RTD with a 250-μA current excitation is approximately 95 μV/°C. Therefore, setting the isolation amplifier's gain to 105 will result in an output sensitivity of 10 mV/°C for a temperature range of 0 to 500°C. With this amplification, the amplifier's output will span a 0 to −5V output range. By connecting IC_3's OUT HI pin to ground (CLK COM) and using OUT LO as the output, the circuit inverts the output range to 0 to 5V.

The gain equation of the circuit in **Fig 3** is the same as the equation for **Fig 2** except for the additional excitation current term, IS_2, as follows:

$$\text{Gain} = (R_F/R_I + 1)$$

$$= (V_{HI} - V_{LO})/IS_2(V_{TC\text{-}HI} - V_{TC\text{-}LO}).$$

If you let R_I equal 100Ω, R_F should be 10.5 kΩ for a 0 to 500°C temperature range.

Fig 3's RTD circuit requires offset and gain calibration similar to that of the thermocouple-conditioning circuit. The easiest calibration method is to substitute a known resistance in place of the RTD. By replacing the RTD with a 100Ω resistor you can simulate a temperature input of 0°C. Then you can adjust the offset-trimming potentiometer, R_2, so that IC_3's output is 0V. Then exchange the 100Ω resistor with one that simulates the RTD at 500°C (280.9Ω, DIN 43 760 standard), and trim the reference voltage until the IC_3's output equals 5V.

A 100Ω platinum RTD that has a 250-μA excitation current and is amplified by a gain of 105 V/V will display a referred-to-output (RTO) sensitivity of 10.1 mV/°C. The circuit's RTO offset and gain drift is 433.2 μV/°C and 360 μV/°C, respectively. This offset and gain drift yields a total sensitivity to ambient temperature changes of 0.079°C/°C.

Condition strain-gauge signals

Another popular class of transducers used in fluid-flow monitoring (and in stress and strain measurements) are pressure transducers and strain gauges. Most of these transducer types consist of resistive elements whose resistance fluctuates in response to mechanical forces. These resistors, like RTDs, need an excitation signal and zero suppression. A common method of implementing these transducers is by placing them into one or more legs of a Wheatstone bridge. A differential amplifier then amplifies the small signal imposed on a large common-mode dc voltage.

Fig 4 shows a simple and accurate method of exciting and conditioning a strain gauge using the bridge approach—and without having to use a costly differential amplifier. This circuit connects a 100-mV strain gauge to the ±5V excitation signal derived from a precision voltage reference, IC_1. This reference contains a 10V buried-zener reference, half-bridge completion resistors (R_1 and R_2), and four amplifiers. Amplifier A_1

Thermocouples have cold-junction errors and voltage nonlinearity errors that complicate accurate temperature measurements.

performs as a ground-servo amplifier for zero suppression, and output amplifiers A_2 and A_3 add remote-sense capability. **Fig 4** configures IC_1 for ±5V operation with emitter-follower current boosters Q_1 and Q_2 to power the strain gauges. The current boosters can supply as much as 10 mA of load current into a 500Ω strain gauge. This current is limited by power limitations of the booster transistors, the power clock, and the saturation flux of the power transformer.

The ground-servo amplifier, A_1, and half-bridge completion resistors, R_1 and R_2, turn an otherwise differential measurement into a single-ended one. A_1 senses the reference voltage via pins 11 and 10 and forces its midpoint to zero. Thus, it forces the bridge to operate symmetrically around ground. If you need to make a remote measurement in cases where the lead resistance in the bridge can cause significant measurement errors, this circuit runs the sense leads of A_2 and A_3 to the remote strain gauge. A_2 and A_3 drive the bases of Q_1 and Q_2 such that the remote sense point will be V_{REF} ±5V.

Fig 4 amplifies a 100-mV, ground-referenced transducer signal by 50 to produce a ±5V output range. As in the previous circuits, you determine the isolation amp's gain by using the standard noninverting gain formula: $R_F/(R_I+1)$.

If you're using a 500Ω strain gauge that requires more than 10 mA, you'll need to add more power to the circuit. You can derive useful power from the power clock by using a simple half-wave rectifier, filter, and transformer comprising T_1, D_1, D_2, and 4.7-μF capacitors. The power clock's $15V_{p-p}$, 25-kHz square-wave output provides the necessary current to supply 20 mA dc from the ±8V output of the unregulated, isolated power supply. Because the AD588 voltage reference requires a maximum of 10 mA, 10 mA are available to the strain gauge.

Consider an alternative

Keep in mind that these voltage-output circuits require an external, unity-gain buffer amplifier, if you plan to drive a load that is less than 1 mΩ. As an option to all of the previous signal-conditioning circuits, you can convert the output voltage of the AD208 isolation

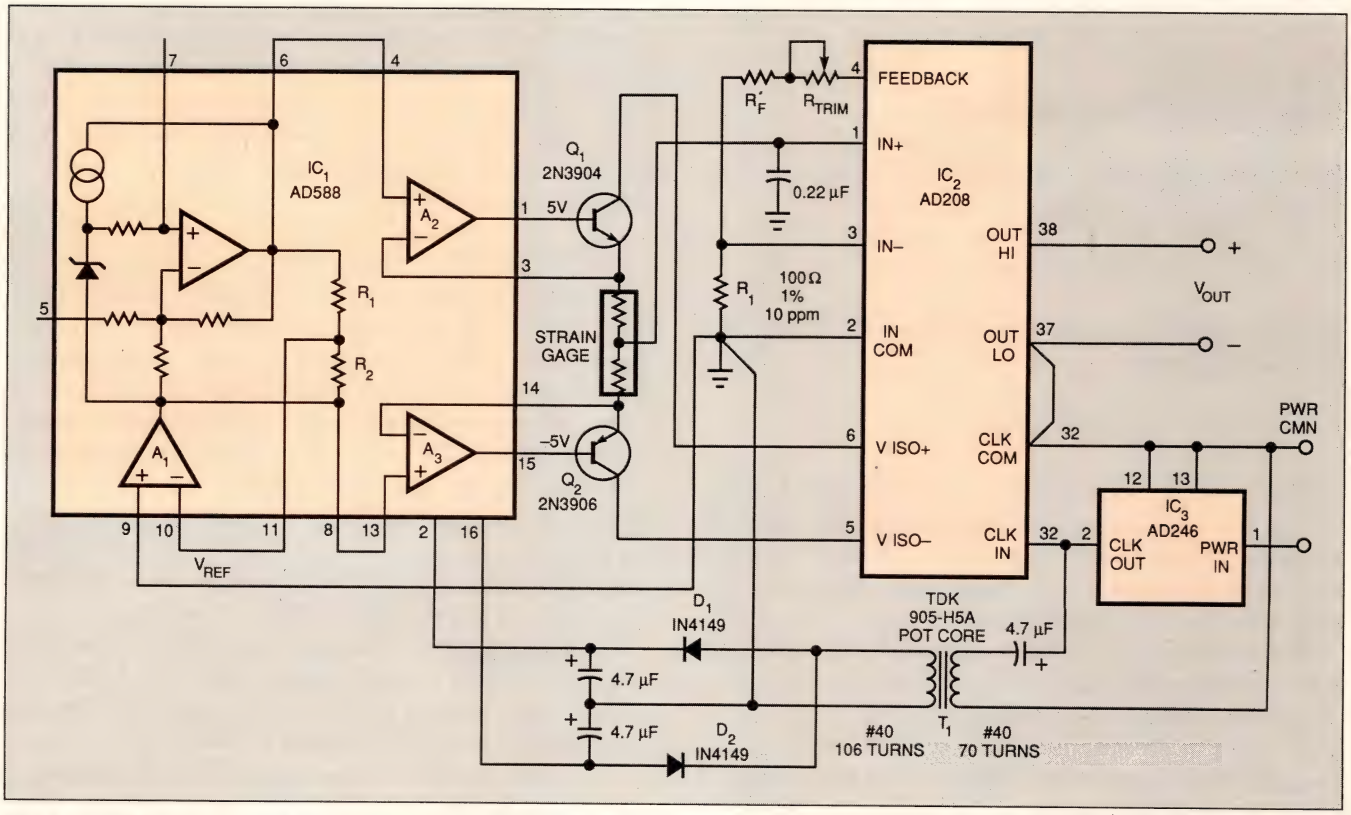


Fig 4—Amplifier A_1, part of a programmable voltage reference, *senses the reference midpoint and forces the bridge to operate around that value. T_1 and its associated components add power if needed.*



Increased density has challenged our engineers for quite some time.

More capability in less space. That's our goal. At Precision Interconnect we pursue it every day for the world's leading electronic equipment manufacturers.

Working with strict mechanical and electrical requirements, we design and produce complete interconnect systems. We manufacture microminiature cables with conductors as small as 42 AWG and terminate them to our standard line of Micro-D and linear strip connectors with .050"(1.27mm) centerline spacing. Custom and nano strip connectors with .025"(.64mm) spacing can also be assembled. When applications require even more density, multiple flexing, or protection from harsh environments, we incorporate specific features to meet those needs.

Our expertise, increasing with each unique problem we solve, ensures that all critical components of your interconnect system are designed in, built in, and tested. And that system will be as compact and reliable as possible. Because at PI, space has always been a precious commodity.

Just give us a call.



Linear strips add modularity to the termination scheme for this Precision Interconnect multi-coax cable assembly.

CIRCLE NO. 86

PRECISION INTERCONNECT

16640 S.W. 72nd Avenue
Portland, OR 97224
(503)620-9400

Offices in San Francisco, Dallas, Wilmington and Düsseldorf.

Resistance temperature detectors (RTDs) offer better stability and linearity than thermocouples, but have a narrower operating-temperature range.

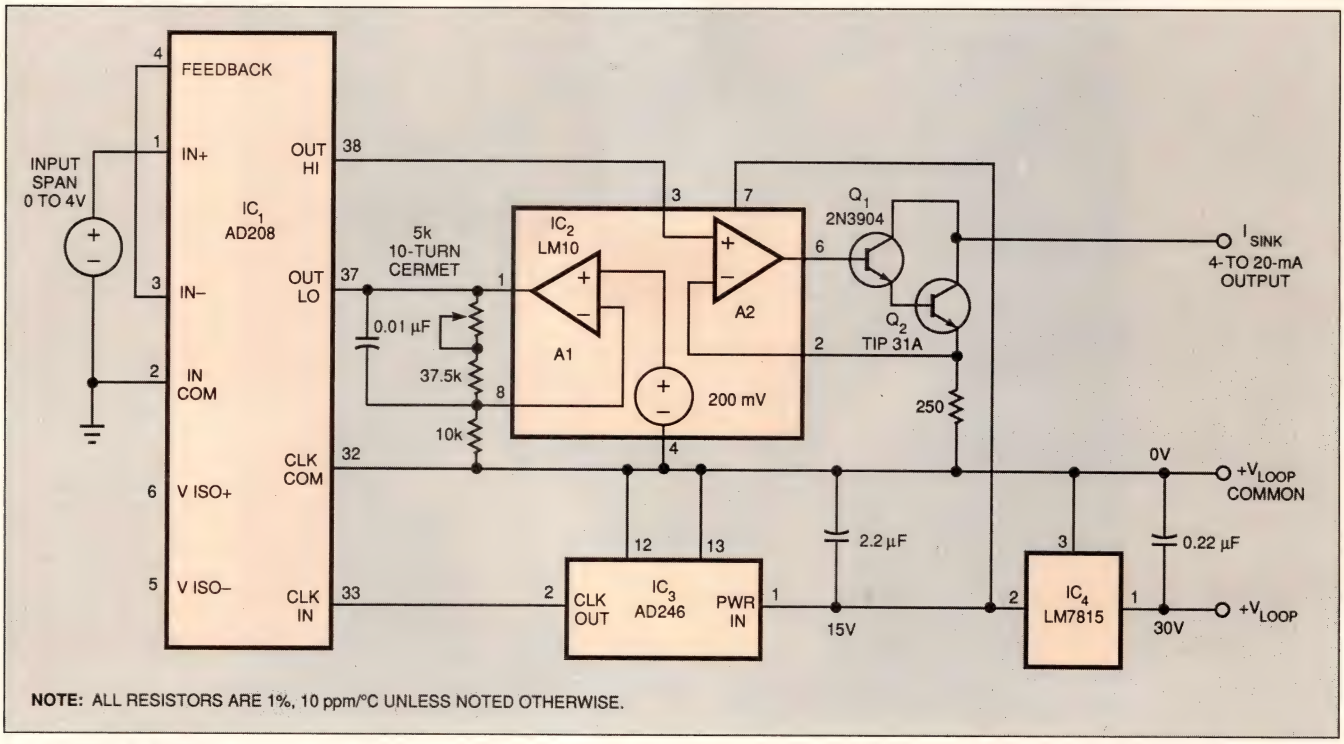


Fig 5—This 4- to 20-mA current-loop circuit *isolates the offset adjustment at the OUT LO pin, from the gain adjustment at the input.*

amplifier to a 4- to 20-mA current (**Fig 5**). IC_1's common-mode output range, OUT LO – CLK COM, allows you to offset the OUT LO pin, thereby providing the offset necessary for the voltage-to-current conversion. IC_2's A_1 amplifies the 200-mV reference by 5, and drives OUT LO to 1V. You can then select resistor values to fix the gain of the AD208 such that the normal-mode output range is 0 to 4V. One requirement of this circuit is that the output common-mode voltage plus the normal-mode voltage must be less than or equal to 6V.

IC_1's OUT HI drives a voltage-to-current converter comprising A_2, Q_1, Q_2, and a 250Ω resistor. This converter generates the requisite 4- to 20-mA output with as much as 25V of compliance for a 30V supply. The circuit connects Q_1 and Q_2 in a Darlington configuration to keep base-current errors to a minimum. Q_2 must dissipate as much as 600 mW over your desired operating temperature range. Therefore, a medium-power transistor such as a TIP 31A works best. You can trim the 4-mA offset by adjusting the gain of A_1 and then independently adjusting the span at the input side of IC_1. This independent adjustment minimizes the interaction between offset and input span commonly encountered in other circuits.

IC_4, an LM7815 voltage regulator, preregulates a 30V input and supplies 15V to the power oscillator. If you are using more than a couple of isolation amplifiers in a multichannel application, you need to be aware that the AD208 isolation amplifier, in combination with the AD246 oscillator, represents a reactive load to your preregulator. Higher-than-average currents can flow into IC_3 and can force your preregulator to go into current limiting. **EDN**

Author's biography



Jeffrey A Greenwald is a project engineer with Analog Devices (Norwood, MA), where he designs and develops isolation and signal-conditioning products. He has been with the company for nine years. Jeff has a BSEE from Northeastern University. In his spare time, he enjoys cabinet making and gardening.

Article Interest Quotient (Circle One)
High 494 Medium 495 Low 496

BOURNS



Best Trimmer For Worst Case Processing.

The surface mount assembly process subjects components to the most severe environments that they will ever likely encounter.

Bourns Trimpot kept that fact in mind when designing its 4mm sealed Model 3314 trimmer. From placement to soldering to cleaning, this rugged single-turn trimmer is compatible with all popular surface mount manufacturing processes.



Applications versatility also describes the Model 3314. It's ideal for oscilloscopes, power supplies, signal generators, satellites, computers, cellular phones, pagers, video cameras, radar detectors, robotics and more.

The Model 3314 delivers performance too. This trimmer's hoe-tipped multi-wire wiper reduces contact resistance variation and noise. Temperature coefficient is superior, thanks to a stable thick film cermet element. Its silicone rubber O-ring creates a permanent seal with very low backlash.

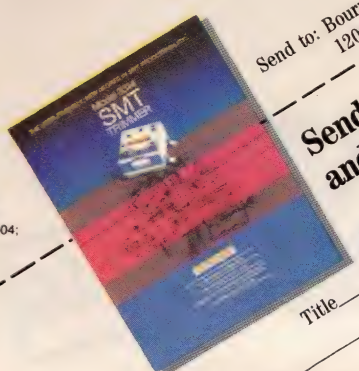
For applications that require surface mount assembly, plan for the worst by specifying the best... the Bourns Model 3314 trimmer.

BOURNS®

THERE'S STILL NO EQUIVALENT

Bourns, Inc., 1200 Columbia Avenue, Riverside, California 92507; (714) 781-5500; European Headquarters: Zugerstrasse 74, 6340 Baar, **Switzerland:** 042-333333; **Benelux:** 070-874400; **France:** 01-40033604; **Germany:** 0711-22930; **Ireland:** 021-357001; **United Kingdom:** 0276-692392; Asia Pacific Headquarters: 1401 Citicorp Centre, 14th Floor, 18 Whitfield Road, **Hong Kong:** (852) 5-702171; **Singapore:** (65) 339-3331; **Korea:** (82) 556-3619; Japan Headquarters: 2nd Floor, Time 24 Building, #35 Tansu-cho, Shinijukuku, Tokyo, 162, **Japan:** (03) 260-1411

Circle 199, Send Literature
Circle 198, Call Me



Send to: Bourns, Inc., M/S ADV
1200 Columbia Ave., Riverside, CA 92507

Send me my FREE 3314 brochure and FREE sample offer

Name_____
Title_____
Company_____
Address_____
City_____ State_____ Zip_____

EDN062190

COPYRIGHT© 1989, BOURNS, INC. 7/89

Looking for a job doesn't have to be one.

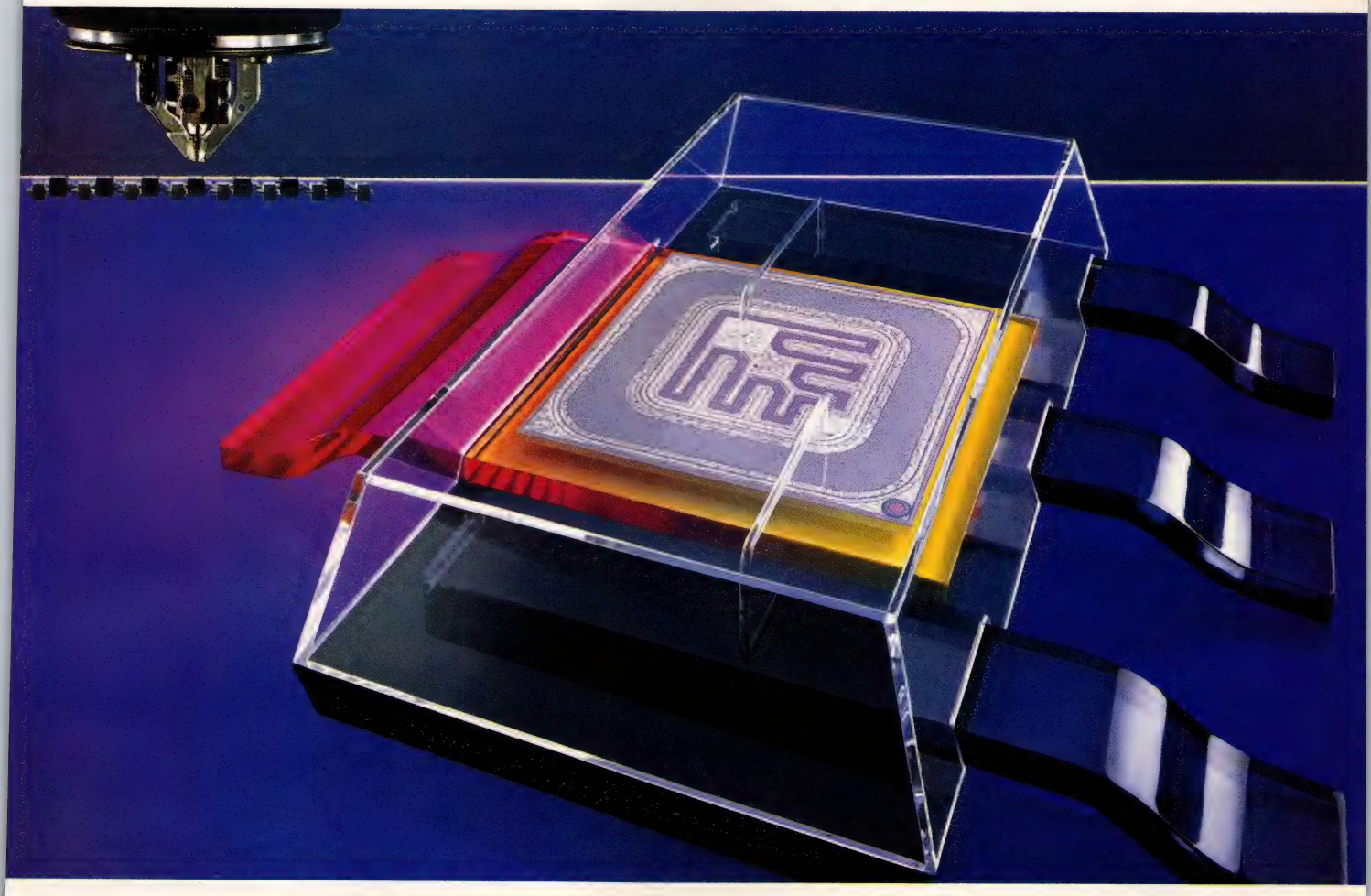
EDN's Career Opportunities section keeps you informed of current job openings from coast-to-coast

TURN TO PAGE 340

The best address for Siemens Semiconductors:

(A) **Wien**
Tel. (0222) 71711-5661
(AUS) **Melbourne, Vic. 3121**
Tel. (03) 4207111
(B) **Bruxelles**
Tel. (02) 536-2111
(BR) **São Paulo-SP**
Tel. (011) 833-2211
(CDN) **Mississauga L5T 1P2**
Tel. (416) 564-1995
(CH) **Zürich**
Tel. (01) 495-3111
(D) **Berlin 10**
Tel. (030) 3939-1
Düsseldorf 1
Tel. (0211) 399-0
Frankfurt 1
Tel. (069) 797-0
Hamburg 1
Tel. (040) 2889-0
Hannover 81
Tel. (0511) 877-0
München 80
Tel. (089) 9221-4380
Nürnberg 1
Tel. (0911) 654-0
Stuttgart 1
Tel. (0711) 2076-0
(DK) **Ballerup**
Tel. (42) 656565
(E) **Madrid**
Tel. (01) 5554062
(F) **Paris**
Tel. (1) 4922-3810
(GB) **Sunbury on Thames**
Tel. (0932) 752615
(GR) **Amaroussio**
Tel. (01) 6864-111
(HK) **Hongkong**
Tel. 5-8330222
(I) **Milano**
Tel. (02) 6766-4241
(IND) **Bombay 400018**
Tel. 4938786
(IRL) **Dublin**
Tel. (01) 3028 55
(J) **Tokyo 100**
Tel. (03) 201-2401
(N) **Oslo 5**
Tel. (02) 633000
(NL) **Den Haag**
Tel. (070) 3333333
(P) **Alfragide**
Tel. (01) 4183311
(RA) **Buenos Aires**
Tel. (01) 300411
(RC) **Taipei**
Tel. (02) 5234700
(ROK) **Seoul**
Tel. (02) 275-6111
(S) **Stockholm**
Tel. (08) 7281000
(SF) **Helsinki**
Tel. (9) 0510 51
(SGP) **Singapore 0513**
Tel. 7760044
(TR) **Istanbul**
Tel. (01) 1510900
(USA) **Iselin**
Tel. (201) 906-4300
Santa Clara
Tel. (408) 980-4500
Cupertino
Tel. (408) 725-7910
(ZA) **Johannesburg**
Tel. (011) 407-4111

SIEMENS



Powerful chips packaged right

New SMD package SOT 223 – for power up to 1.5 W

The new SOT 223 package from Siemens was created with powerful chips in mind. Without any extra cooling it can dissipate up to 1.5 W.

SOT 223 is ideal for all substrates – even epoxy. And you can put it through any kind of soldering process, wave soldering too. The package measures 6.5 by 3.5 by 1.6 mm and is available right away on 12- mm tapes.

SOT 223 comes with a variety of powerful chips, for applications in industrial, automotive, consumer and entertainment electronics.

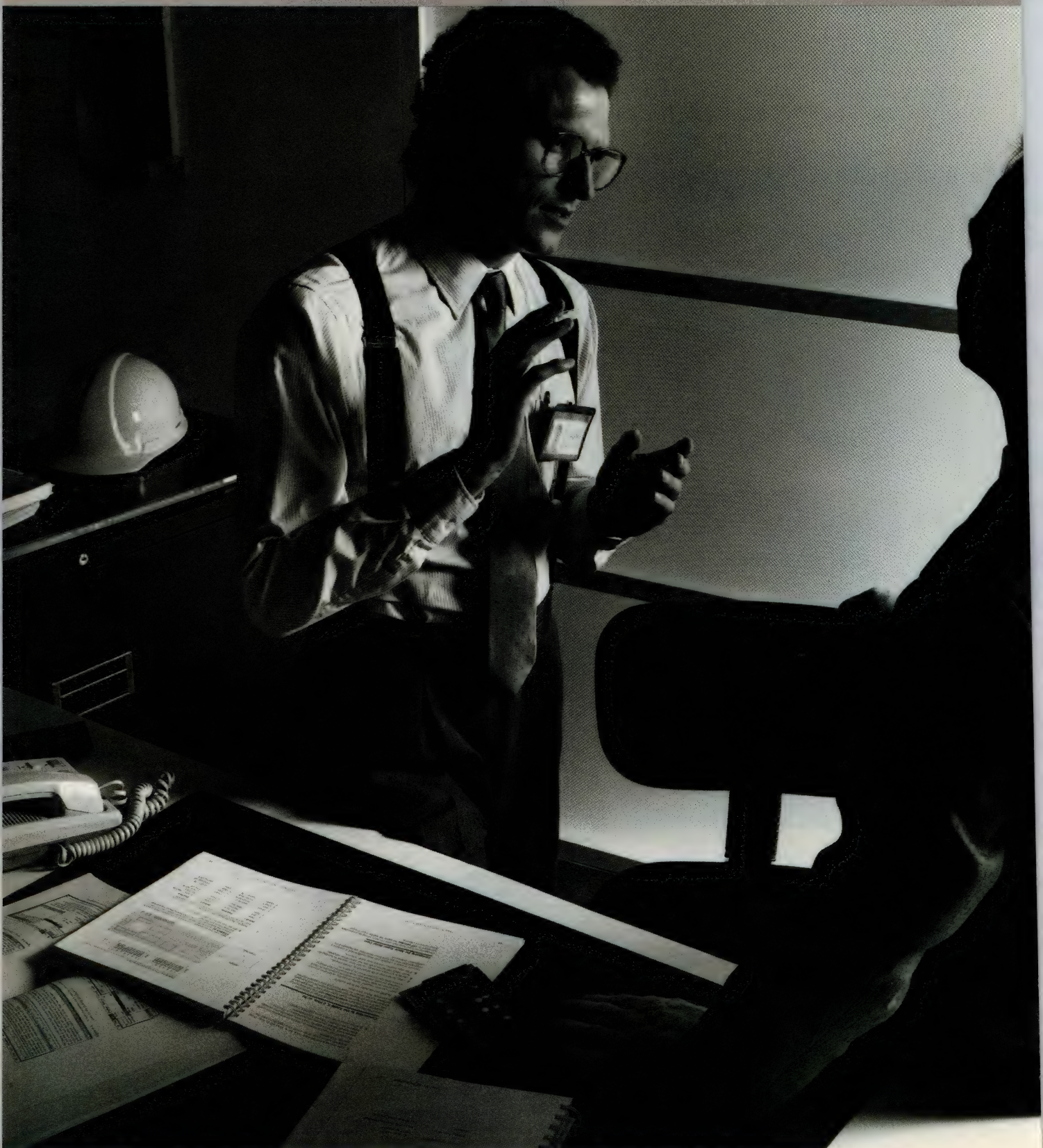
For full details by return post write Siemens AG, Infoservice, HL 3206, Postfach 2348, D-8510 Fürth quoting "SOT 223 power package".

TopTech Semiconductors Siemens

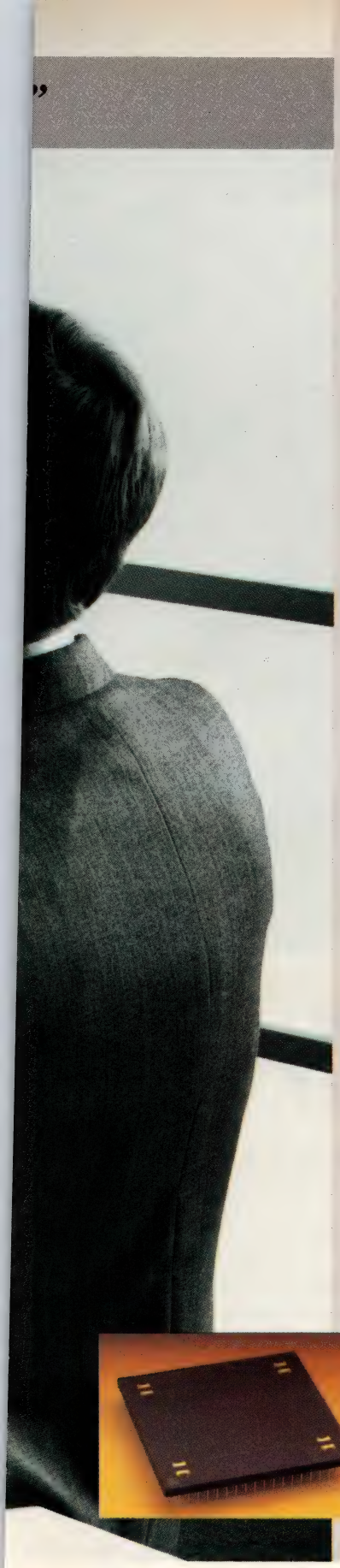
A19100-HL3206-X-7600

CIRCLE NO. 88

"I'll bet Toshiba's new 172,000-gate array could han



AREA SALES OFFICES: CENTRAL AREA, Toshiba America Electronic Components, Inc., (708) 945-1500; **EASTERN AREA,** Toshiba America Electronic Components, Inc., (617) 272-4352; **NORTHWESTERN AREA,** Toshiba America Electronic Components, Inc., (408) 737-9844; **SOUTHWESTERN REGION,** Toshiba America Electronic Components, Inc. (714) 259-0368; **SOUTH CENTRAL REGION,** Toshiba America Electronic Components, Inc., (214) 480-0470; **SOUTHEASTERN REGION,** Toshiba America Electronic Components, Inc., (404) 368-0203; **MAJOR ACCOUNT OFFICE, FISHKILL, NEW YORK,** Toshiba America Electronic Components, Inc., (914) 896-6500; **MAJOR ACCOUNT OFFICE, BOCA RATON, FLORIDA,** Toshiba America Electronic Components, Inc., (305) 394-3004. **REPRESENTATIVE OFFICES: ALABAMA,** Montgomery Marketing, Inc., (205) 830-0498; **ARIZONA,** Summit Sales, (602) 998-4850; **ARKANSAS,** MIL-Reps, (214) 644-6731; **CALIFORNIA** (Northern) Elrepco, Inc., (415) 962-0660; **CALIFORNIA** (L.A. & Orange County) Bager Electronics, Inc., (818) 712-0011, (714) 957-3367, (San Diego County) Bager Electronics, Inc., (619) 632-8816; **COLORADO,** Straube Associates Mountain States, Inc., (303) 426-0890; **DELAWARE,** Nexus Technology, (215) 675-9600; **DISTRICT OF COLUMBIA,** D.G.R., Inc., (301) 583-1360; **FLORIDA,** Sales Engineering Concepts, (407) 682-4800, (305) 426-4601; **GEORGIA,** Montgomery Marketing, Inc., (404) 447-6124; **IDAHO,** Components West, (509) 922-2412; **ILLINOIS,** Carlson Electronic Sales, (708) 956-8240, R.W. Kunz, (314) 966-4977; **INDIANA,** S.T.B. And Associates, (317) 844-9227; **IOWA,** Carlson Electronics, (319) 378-1450; **KANSAS,** D.L.E. Electronics, (316) 744-1229; **KENTUCKY,** S.T.B. And Associates, (502) 499-6404; **LOUISIANA,** MIL-Reps, (713) 444-2557; **MARYLAND,** D.G.R., Inc., (301) 583-1360;



"Think of what we could do with 33% more gates."

"And think how much board space the increased density would save us."

"Without sacrificing speed. It's still under 400 pico-second gate delay."

"I wonder how fast we can get our hands on one."

"How fast can you dial that phone?"

The new TC140G Series packs 172,000 gates on a single chip. Yet the delay time is under 400 picoseconds—about 5% better than our own industry-leading TC120G Series. And the die is smaller too. Even though the maximum gate count is 33% higher.

Chalk up one more success to our 1.0 micron CMOS technology. And to our proven Sea of Gates non-channeled architecture.

The TC140G Series is upwardly compatible from the TC120G. It is supported by a compatible library of over 500 cells. Plus compatible CAD tools like our VLCAD System.

TOSHIBA THE POWER IN GATE ARRAYS		
SERIES	TC120G	TC140G
GATES	37,932 to 129,042	2,300 to 172,000
GATE LENGTH	1.0μ	1.0μ
GATE SPEED	0.4ns	0.4ns
PART NUMBERS	5	14
AVAILABILITY	NOW	NOW
All Si-gate double layer metal.		

The combination of high density and high speed make the TC140G Series especially well-suited to high performance applications. Applications like mainframe CPUs, minicomputers and telecommunications switching.

But even if you don't need all those gates, you can still benefit from the TC140G's high performance. The Series is available in 14 master array sizes ranging from 2000 gates on up to 172,000. One is sure to be right for your ASIC application.

Now there are five Toshiba design centers around the United States to help you. For technical literature call 1-800-888-0848 ext. 517 today. *Service is our key component.*

In Touch with Tomorrow

TOSHIBA

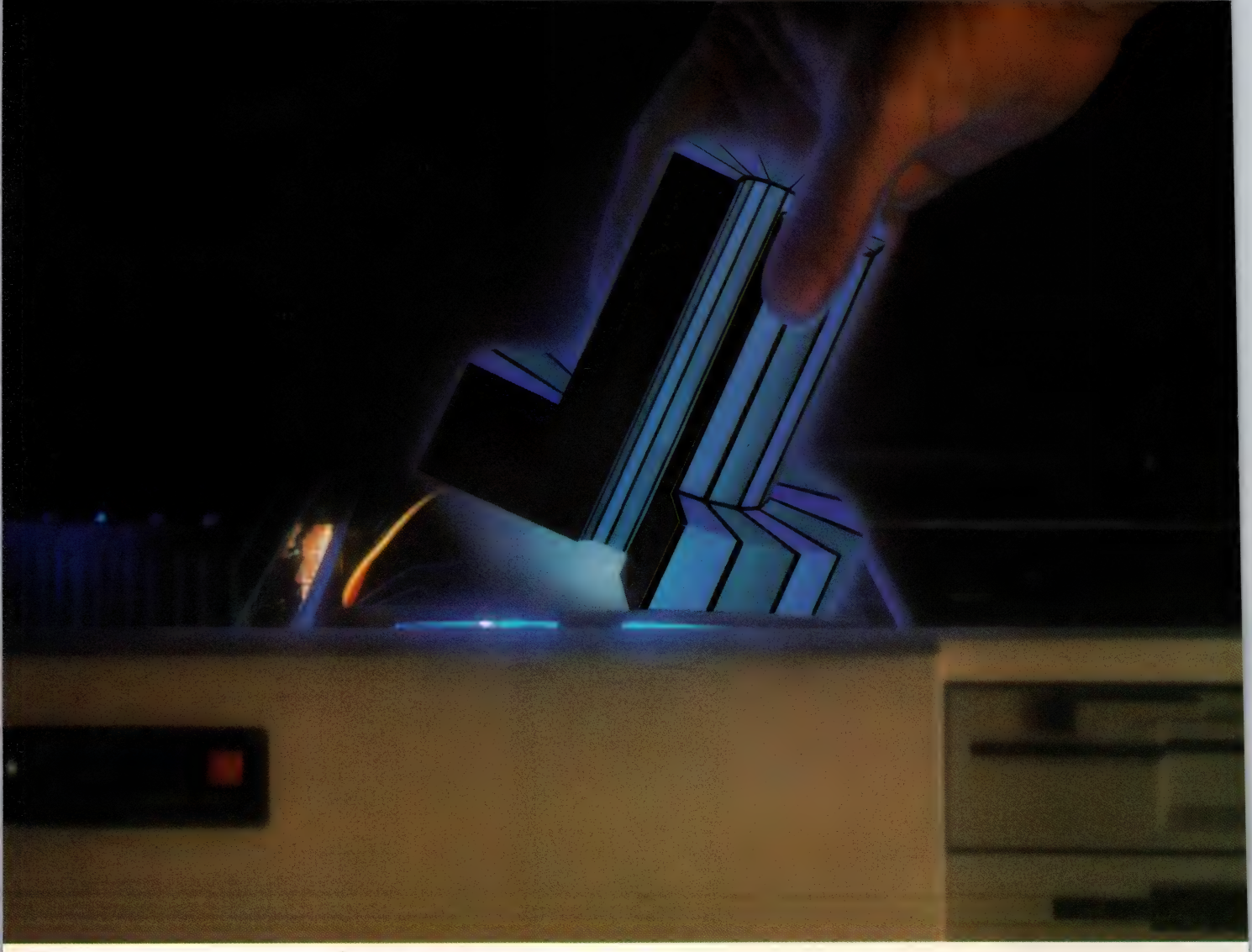
TOSHIBA AMERICA ELECTRONIC COMPONENTS, INC.

© 1989 Toshiba America Electronic Components, Inc.

CIRCLE NO. 89

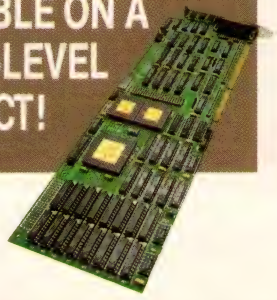
MAS-89-011-1

MICHIGAN, Action Components Sales, (313) 349-3940; **MINNESOTA,** Electric Component Sales, (612) 933-2594; **MISSISSIPPI,** Montgomery Marketing, Inc., (205) 830-0498; **MISSOURI,** D.L.E. Electronics, (316) 744-1229, R.W. Kunz, (314) 966-4977; **MONTANA,** Components West, (206) 885-5880; **NEVADA,** Elrepco, Inc., (415) 962-0660; **NEW JERSEY,** Nexus Technology, (201) 947-0151; **NEW MEXICO,** Summit Sales, (602) 998-4850, (505) 345-5003; **NEW YORK,** Nexus Technology, (201) 947-0151; **NEW YORK** (Upstate), L.D. Allen, (315) 437-8387; **NORTH/SOUTH CAROLINA,** Montgomery Marketing, Inc., (919) 467-6319, (919) 851-0010; **NORTH/SOUTH DAKOTA,** Electric Component Sales, (612) 933-2594; **OHIO,** J.R. Thornberry, (216) 248-4995, (614) 792-5171; **OKLAHOMA,** MIL-Reps, (214) 644-6731; **OREGON,** Components West, (503) 684-1671; **PENNSYLVANIA,** Nexus Technology, (215) 675-9600, (Western), J.R. Thornberry, (412) 745-8441; **TENNESSEE,** Montgomery Marketing, Inc., (205) 830-0498; **TEXAS,** MIL-Reps, (512) 346-6331, (713) 444-2557, (214) 644-6731; **UTAH,** Straube Associates Mountain States, Inc., (801) 263-2640; **VIRGINIA,** D.G.R., Inc., (301) 583-1360; **WASHINGTON,** Components West, (206) 885-5880, (509) 922-2412; **WEST VIRGINIA,** D.G.R., Inc., (301) 583-1360; **WISCONSIN,** Carlson Electronics, (414) 476-2790, Electric Component Sales, (612) 933-2594; **WYOMING,** Straube Associates Mountain States, Inc., (303) 426-0890; **CANADA, BRITISH COLUMBIA,** Electro Source, (204) 888-2412; **ONTARIO,** Electro Source, Inc., (416) 675-4490, (613) 592-3214; **QUEBEC,** Electro Source, Inc., (514) 630-7486.



Could your system use a live-in supercomputer?

33 MFLOP PERFORMANCE NOW AVAILABLE ON A BOARD-LEVEL PRODUCT!



Complex applications can run at supercomputer speed on your AT – **if** you build in ASPI's Banshee® co-processor motherboard!

Banshee will pull your AT up to 33 MFLOP performance for such critical activities as image processing, speech recognition, robotics and other computation-intensive applications. DSP technology makes Banshee the ideal solution whenever high-speed high-volume calculations are required.

Plug Banshee into one of the expansion slots on your AT. Use the ASPI-provided development package (hardware, software, manuals, SPOX® C30 operating system and DOS shell program) to refine your application and go to work. With a variety of daughter-board options, you can also add such enhancements as memory expansion, A/D-D/A and microprocessor capabilities. Enjoy supercomputer performance at only a fraction of supercomputer investment!

For detailed specs, prices and/or immediate shipment, contact Atlanta Signal Processors, Inc., 770 Spring Street, Atlanta, GA 30308. Telephone 404/892-7265. FAX 404/892-2512.

aspi

WORLD LEADERS IN DSP DESIGN TOOLS

Compression algorithms reduce digitized images to manageable size

Unfortunately, the number of bits in a digitized image can be huge—so large that storing or transmitting digitized images is impractical without reducing the number of bits they comprise. You can use compression algorithms to solve this problem.

William C Warner, *Consultant*

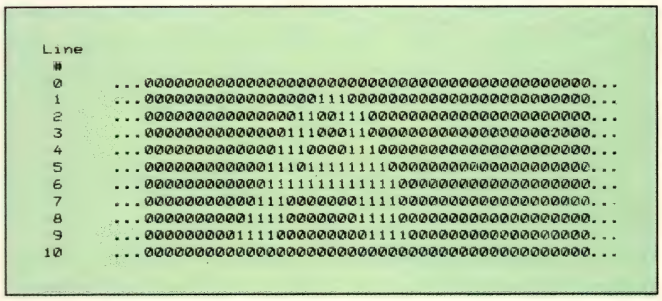
In a computer, engineering drawings, artwork, and other nontext documents exist as digitized images. An image of a C-size engineering drawing (17 × 22 in.) commonly contains more than 14 megabits of data; an image of an E-size drawing (34 × 44 in.) contains more than 57 megabits. Storing or transmitting this much data per image is a problem. Using the algorithms presented in this article, you'll be able to significantly reduce the size of digitized images.

Scanners and video cameras digitize documents, coding them as ones and zeros. These devices examine a large number of spots, of very small area, on the face of a document. They render spots that are sufficiently dark as ones and spots insufficiently dark as zeros (**Fig 1**). In this way a document on paper or microfilm becomes an array of bits—something a computer can store, manipulate, and transmit.

The number of bits in an image depends on the size of the original document and the resolution at which you scan it. Resolution is a measure of precision. The unit for resolution is dots per inch (dpi). The resolution squared is the number of spots a scanner or camera examines and digitizes in one square inch of the original document. Common resolutions are 100, 150, 200, 240, and 300 dpi. Industry is standardizing on 200 dpi for engineering documents.

The greater the resolution, the more like the original the digitized image will appear when the computer displays or prints it. Because the quality goes up as the resolution goes up, increasing the resolution seems attractive. But the amount of data you get rises with the square of the resolution, so practical limits come up quickly.

Therefore, designers look for ways to reduce the amount of data in images without reducing the resolu-


Line
#
0 ...@@@

The greater the resolution, the more like the original the digitized image will appear when the computer displays or prints it.

tion and losing information. They solve this problem by encoding the data in special ways. The encoding, called compression, results in less data—often much less. The amount of data before compression divided by the amount after compression is the compression ratio. You decompress, or expand, compressed data to recover the original, raw-image bits.

The simplest compression algorithms yield compression ratios of 2:1, sometimes 5:1. The most sophisticated compression algorithms achieve 10:1, often 20:1. And nothing gets lost. Hardware or software can recover the full-blown image, bit for bit, from the compressed data.

The better algorithms work so well and are in such wide use that CCITT has issued standards for them, and IC makers offer chips that compress data in accordance with these standards (**Ref 1**). A fast CPU can also compress images using software. Compressing by software is slower than by hardware, but designers sometimes offer software compression as an option for applications where reduced speed is acceptable.

Like any specialized field, data compression has its own vocabulary. For example, common terms for uncompressed image data are *bit mapped*, *raster*, or *raw*. Think of the uncompressed image data as an array of bits or pixels (**Fig 1**). One row of the array corresponds to one line of a document. At 200 dpi, a document has 200 lines per vertical inch, and each line has 200 pixels per horizontal inch. Usually, the number of pixels in each line divides evenly by eight so that lines end at byte boundaries. The pixels' values are color coded: Ones are black and zeros are white (although some systems reverse the color assignments).

A "run" is a succession of pixels all of one color. Runs alternate in color and stop at the end of lines. "Run length" is the number of pixels in a run. A busy image has a small average run length, and a clean image has a large average run length. Compression is greater and occurs faster on images with a large average run length. Very busy portions of an image may suffer negative compression; that is, compression may produce more data than it replaces (a compression ratio less than one).

Hardware will compress or expand a typical 300-dpi A-size image in three to four seconds, using the most efficient algorithms. Software takes somewhat longer. With a 20-MHz 80386 CPU, software compresses or expands the same image in six to seven seconds. (These times include writing or reading the compressed data—typically 55k bytes—to or from a hard disk.) Larger images compress and expand in proportionally longer times, unless they are significantly more or less busy.

Average run length, or busyness, has the greatest influence on compression and expansion time for software methods (also on the degree of compression). The shorter the average run, the more runs the software must handle. Converting between raw data and run lengths accounts for a large part of processing time. The routines that perform these operations should execute efficiently; you'll probably have to write them in assembly language. The total time to process an image is, essentially, the product of the time to process a run, the average number of runs per line, and the number of lines in the image. Hence, you should strive to process each run as quickly as possible.

Simple run-length encoding is the easiest way to

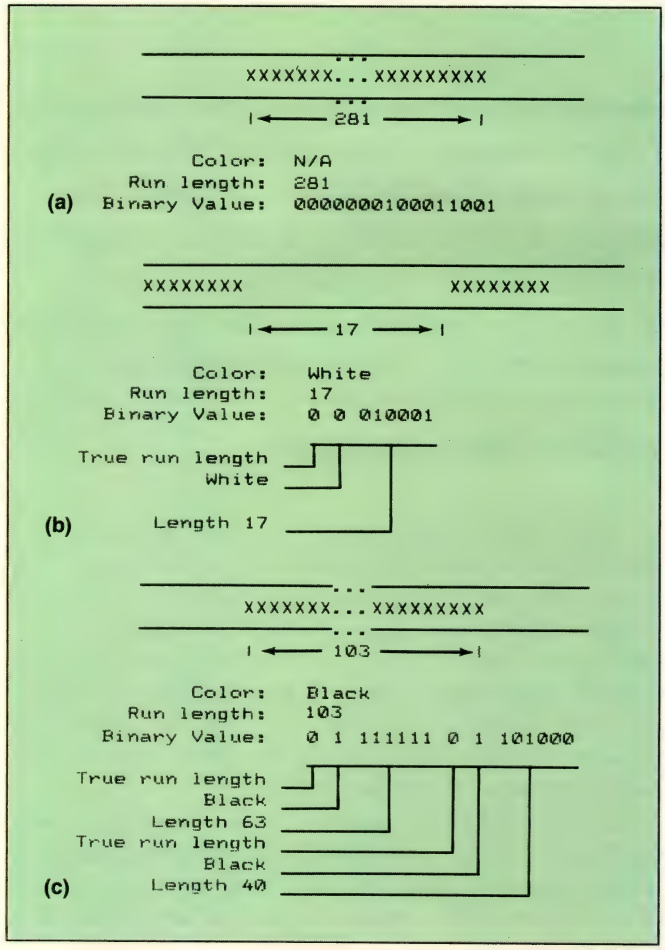


Fig 2—Two-byte, run-length encoding (a) *reduces any pixel run to a 2-byte substitute code. On the other hand, 1-byte encoding can produce 1-byte substitute codes for short runs* ***(b)*** *and sometimes multiple 1-byte codes for long runs* ***(c)****.*

compress image data and is the basis for more sophisticated methods. No standards exist for this simple method, so what follows describes typical implementations.

Run-length encoding replaces runs by their lengths (**Fig 2**). Instead of saving all the pixels in a line, you calculate the lengths of all the runs and save those values. You do this calculation separately for each line. Some schemes store run lengths as 1-byte values; others use two bytes.

The only advantage of 2-byte run-length values is that two bytes can express the largest runs arising in practice. Consequently, your encoded data will be regularly spaced, and successive values will correspond to successive runs. If you assume that every line begins conventionally with a white run, perhaps of zero length, you can infer the color of a given run from its position in the sequence of coded data.

One-byte schemes, on the other hand, must sometimes actually devote two or more values to a single long run, so successive values don't necessarily correspond to successive runs. Consequently, 1-byte schemes must use one bit of each run-length value to denote the color of the run. The sacrifice of another bit means that even more runs may be too long for a single byte to express.

Both methods waste bits. Whenever you store a value with leading zeros, you are using more bits than you need to express that value. You can't eliminate the wasted bits by running values together because, later, you wouldn't be able to find where one value stops and the next begins. Nevertheless, the number of bits that a run-length value takes up—eight or 16—is usually less than the number of pixels it replaces.

Literals handle exceptions

Busy areas of an image sometimes suffer negative compression. Therefore, when doing so will avoid negative compression, some run-length schemes include bytes of literal, unencoded pixels amid the run-length codes. Typically, such schemes use the MSB of a run-length value as a flag to indicate whether the value is

Glossary

Bit-mapped data: Uncompressed image data.
Busy: A busy image has a small average run length.
Clean: A clean image has a large average run length.
Compression: Encoding bit-mapped data in a more compact form.
Compression ratio: The amount of data before compression divided by the amount of data after compression.
Decompression: Recovering the original raw-image bits from compressed data.
dpi: Dots per inch, a measure of resolution or precision.
EOL: End-of-line indicator.
EOP: End-of-page indicator.
G3-1D: CCITT Group 3 one-dimensional. Run-length encoding followed by substituted codes for run-length values.
Horizontal codes: A code that replaces a horizontal run in a 2-D coding scheme.
K: The spacing between 1-D lines of pixels included in a 2-D encoded image for error-recovery purposes.
Negative compression: Compression that produces more data than it replaces (a compression ratio of less than one).
Padding and filling: Extra bits inserted between the end of data and the start of the final EOL code that make the EOL codes, and hence each line, end on a byte boundary. Fill bits flesh out lines that are too short to guarantee a minimum transmission time.
Pass codes: A code used in 2-D encoding schemes.
Raster data: Uncompressed image data.
Raw data: Uncompressed image data.
Run: A succession of pixels all of one color. Runs alternate in color and stop at the end of lines.
Run length: The number of pixels in a run.
Run-length encoding: Replacing runs by their lengths.
Transition points: Every pixel that isn't the same color as its immediate predecessor is a transition, or changing point.
Two-dimensional (2-D) encoding: 2-D encoding exploits normal raw data's regularity by employing very short codes to express a coding line in terms of the line above—the reference line.
Vertical codes: A vertical code used in 2-D encoding schemes.

Compression by software is slower than by hardware, but designers sometimes offer software compression as an option.

a true run length. When it's not a true run length, the value specifies the number of literal, unencoded bytes of pixels that follow.

The study of digitized documents reveals that some run lengths occur much more frequently than others. Researchers determined the probabilities, which are not the same for white and black pixels, and developed tables of codes to substitute for certain run-length values. The codes vary in size, and the tables assign shorter codes to more likely run lengths. More importantly, the codes eliminate wasted bits because you may splice the codes together without respecting byte or word boundaries.

If you assume that a line begins with a white run, perhaps of zero length, then you can analyze the concatenated codes and always find where one code ends and the next begins.

The substitute codes in **Tables 1** and **2** are the basis of the CCITT Group 3 image-data compression algorithms.

Group 3 1-dimensional (G3-1D) encoding is a 2-step process: run-length encoding followed by substituting codes for run-length values. G3-1D is one dimensional because, like simple run-length encoding, it treats each line separately. (Two-dimensional schemes encode one line with reference to its preceding line.) G3-1D typically yields compression ratios of from 5:1 to 10:1.

G3-1D replaces runs of as many as 63 pixels with a single "terminating" code (**Table 1**); it replaces longer runs with a combination of "make-up" codes (**Table 2**)

Table 1—Terminating codes

White codes	Run lengths	Black codes
00110101	0	0000110111
000111	1	010
0111	2	11
1000	3	10
1011	4	011
1100	5	0011
1110	6	0010
1111	7	00011
10011	8	000101
10100	9	000100
00111	10	0000100
01000	11	0000101
001000	12	0000111
000011	13	00000100
110100	14	00000111
110101	15	000001000
101010	16	000000101111
101011	17	000000111000
0100111	18	000000001000
0001100	19	000001100111
0001000	20	000001101000
0010111	21	000001101100
0000011	22	000000110111
0000100	23	000000101000
0101000	24	000000101111
0101011	25	000000110000
0010011	26	000001100101010
0100100	27	000001100101011
0011000	28	000001100110000
00000010	29	000001100111001
00000011	30	000000110100000
00011010	31	000000110100001
00011011	32	000000110101010
00010010	33	000000110101011
00010011	34	000001101000010
00010100	35	000001101000011
00010101	36	000001101010100
00010110	37	000001101010101
00010111	38	000001101011010
00101000	39	000001101011011
00101001	40	000001101100000
00101010	41	000001101101001
00101011	42	000001101101010
00101100	43	000001101101011
00101101	44	000001101010000
00000100	45	000001101010101
00000101	46	000001101010110
00001010	47	000001101011111
00001011	48	000001110010000
01010010	49	000001110010001
01010011	50	000001101000010
01010100	51	000001101000011
01010101	52	000000101001000
00100100	53	000000011011111
00100101	54	000000011110000
01011000	55	000000010001111
01011001	56	000000010100000
01011010	57	000000010110000
01011011	58	000001011001
01001010	59	000000101011
01001011	60	000000101100
00110010	61	000001011010
00110011	62	000001110011
00110100	63	000001100111

Table 2—Make-up codes

White codes	Run lengths	Black codes
11011	64	0000001111
10010	128	000011001000
010111	192	000011001001
0110111	256	000001011011
00110110	320	000000110011
00110111	384	000000110100
01100100	448	000000110101
01100101	512	000000110110
01101000	576	000000110111
01100111	640	000000100101
011001100	704	000000100101
011001101	768	000000100110
011010010	832	000000100111
011010011	896	000000111001
011010100	960	000000111001
011010101	1024	000000111010
011010110	1088	000000111010
011010111	1152	000000111011
011011000	1216	000000111011
011011001	1280	000000101001
011011010	1344	000000101001
011011011	1408	000000101010
010011000	1472	000000101010
010011001	1536	000000101101
010011010	1600	000000101101
011000	1664	000000011001
010011011	1728	000000011001

White or Black Run lengths	Codes
1792	000000001000
1856	000000001100
1920	000000001101
1984	000000010010
2048	000000010011
2112	000000010100
2176	000000010101
2240	000000010110
2304	000000010111
2368	000000011100
2432	000000011101
2496	000000011110
2560	000000011111
EOL	000000000001

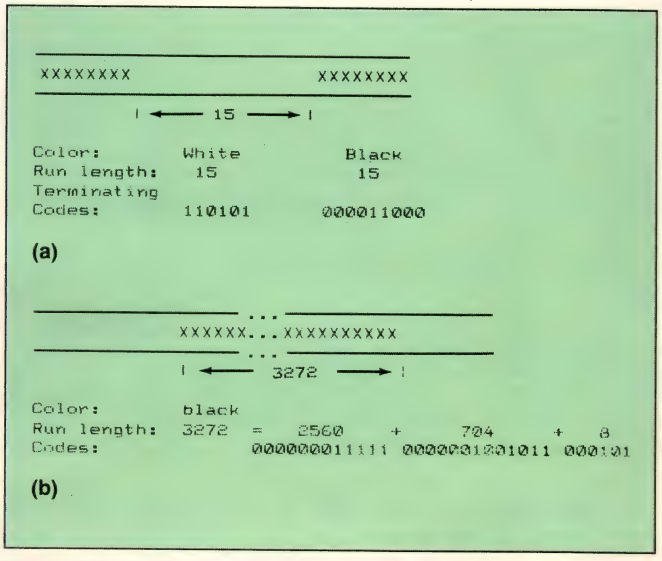


Fig 3—G3-1D encoding of short white and black runs *uses only the terminating codes from* ***Table 1 (a)****. A long run* ***(b)*** *uses both make-up codes from* ***Table 2*** *and a terminating code from* ***Table 1****.*

and, even if the make-up codes express the run exactly, a final terminating code. **Fig 3** gives examples of G3-1D encoding. Images begin and end on byte boundaries. End-of-line (EOL) codes (**Table 2**) mark the start of an image and the end of each line, and an end-of-page (EOP) code (comprising six contiguous EOLs) marks the end of an image. The first run in each line is white, by convention, even if its length is zero.

A few options for this particular standard algorithm are available. You may pad each line with 0-value bits between the end of data and the start of the final EOL code. Such padding makes the EOL codes, and hence each line, end on a byte boundary. You may also specify a minimum line length, in bytes of compressed data, to guarantee that compressed lines, when transmitted, will meet some minimum transmission time. Fill bits (zeros) flesh out lines that are too short (**Fig 4**).

Another option is the order of bits within bytes (**Fig 5**). Image-data bits reside in bytes of computer memory, starting at some address, and filling successive bytes upward into higher memory. The stream of bits (which is the image) can enter each byte at bit seven and leave at bit zero, or enter at bit zero and leave at bit seven. Designers can make the choice of bit order independently for raster and compressed data.

Obviously, to expand compressed images, you must know whether the compressed data includes padding or filling, and you must know the bit order of the compressed and raster data.

The big payback in image compression comes with the step up to 2-dimensional (2-D) encoding. Two-dimensional schemes encode each line with reference to the preceding line. Two-dimensional encoding achieves high compression because, in images of real drawings, many lines differ very little from the lines just above and below them. (A glance back at **Fig 1** will show you that each line differs only slightly from the line above it.) Compression ratios of 10:1 are common, and 20:1 is not uncommon.

Research shows that 75% of transitions from one color to another occur directly below or within one pixel to the left or right of a transition on the line above. Two-dimensional encoding exploits this regularity by employing very short codes to express a "coding" line in terms of the line above—the "reference" line. In places where the coding and reference lines aren't sufficiently similar, 2-D schemes use G3-1D run-length substitution codes to encode that portion of the coding line. Each raw coding line becomes the reference line for its successor.

The important features in a line of pixels are the

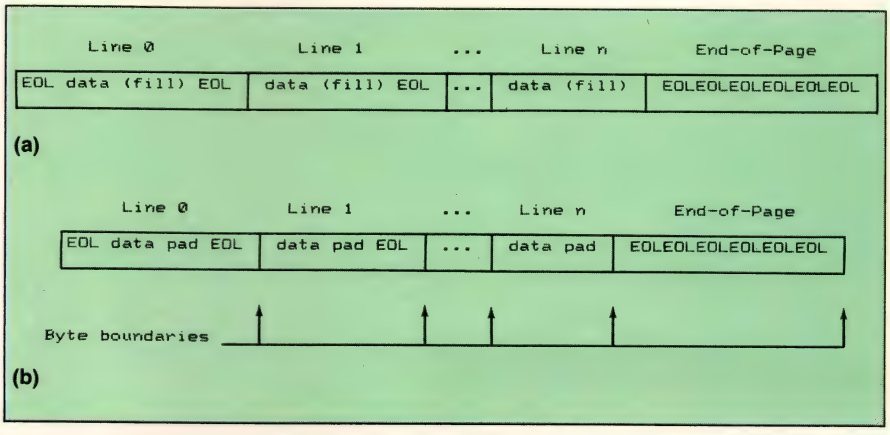


Fig 4—G3-1D encoding allows several options, *such as encoding with optional fill but no byte alignment* ***(a)****, or encoding with byte alignment but no fill* ***(b)****.*

Average run length, or busyness, has the greatest influence on compression and expansion time and also on the degree of compression.

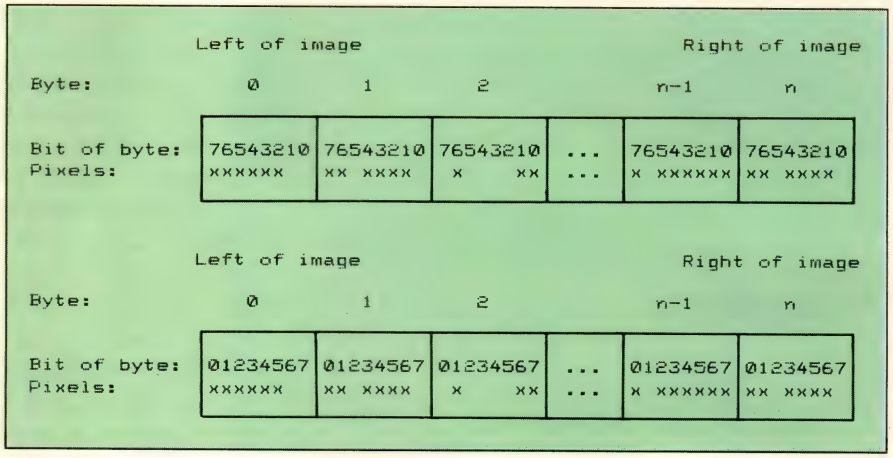


Fig 5—Hardware or software that will work with compressed *images must know which bit-ordering scheme to use.*

points at which the pixels change color. These are transition points, or changing points; every pixel that isn't the same color as its immediate predecessor is a changing pixel. Compression algorithms look for and then classify these changing points before deciding how to encode a line.

For 2-D compression, five changing pixels figure into the encoding of each segment of a line. Their labels and meanings are

- A0: The starting pixel on the coding line. At the start of each line, A0 rests on an imaginary white pixel to the left of the first real pixel of the line. A0 moves to the right as you encode each segment of the line.
- A1: The next changing pixel on the coding line to the right of A0.
- A2: The next changing pixel on the coding line to the right of A1.
- B1: The first changing pixel on the reference line to the right of A0 but of opposite color.
- B2: The next changing pixel on the reference line to the right of B1.

To use the 2-D algorithm, label changing pixels on the coding line and on the reference line **(Fig 6a)**.

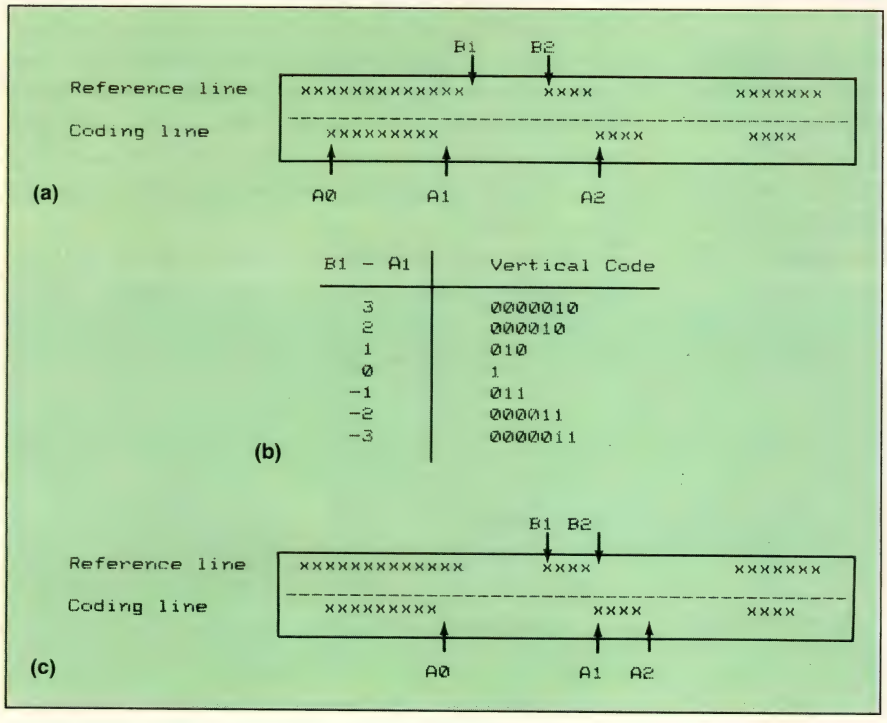
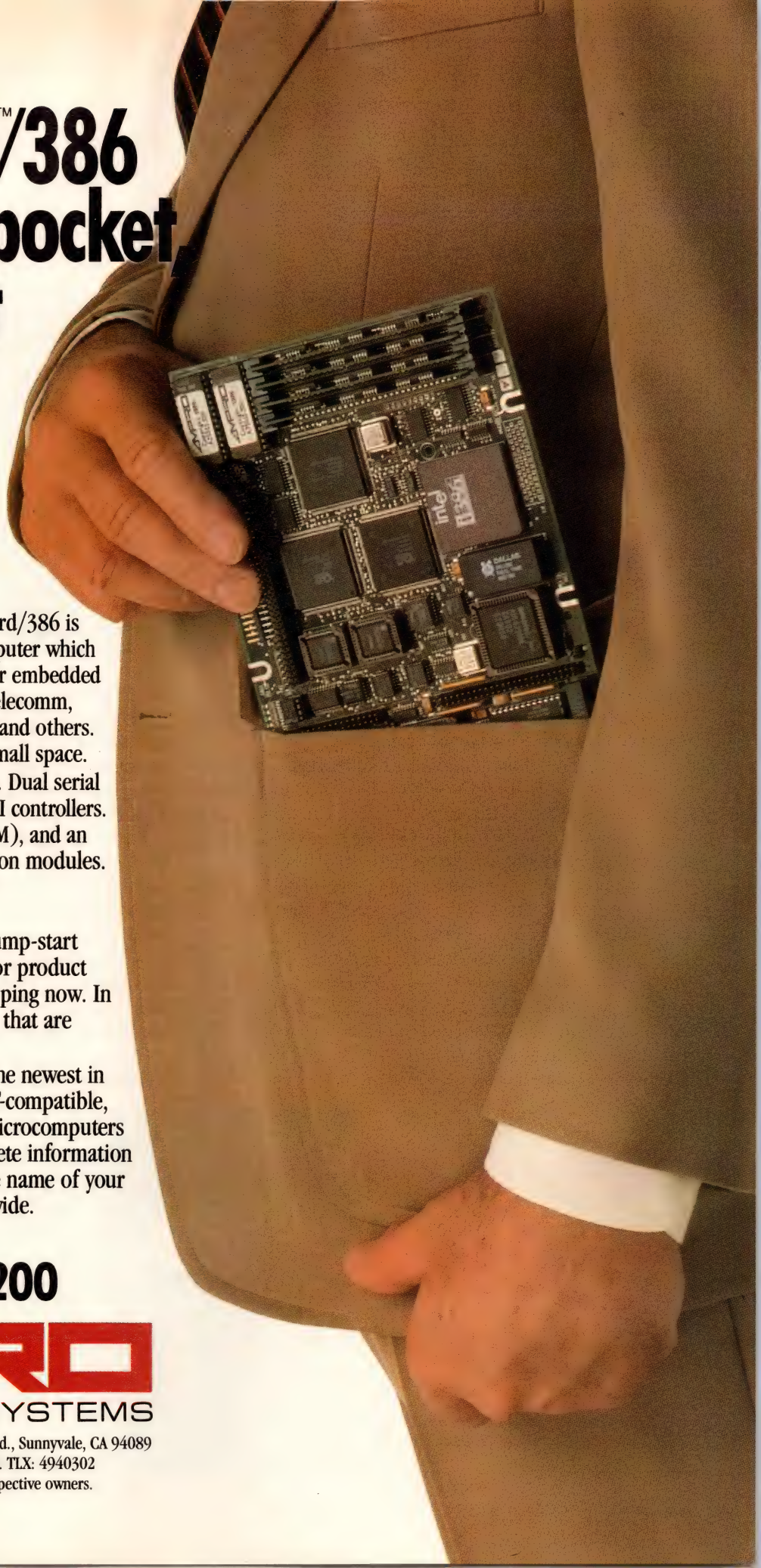


Fig 6—Two-dimensional-encoding algorithms find and label *certain transition points in the reference and coding lines* ***(a)****. Then, if the A1 transition is within 3 bits of the B1 transition, the algorithms replace the run in the coding line up to A1 with the applicable vertical code from* ***(b)****. Next, they reposition the transition labels and repeat the process* ***(c)****.*

If the new Little Board™/386 fits in your pocket, think how it would fit in your product.



Big power. Small package. Little Board/386 is a complete, 32-bit, 20MHz, 80386 computer which occupies just 5.75″ X 8″. It's perfect for embedded applications such as instrumentation, telecomm, network servers, data acquisition, CAM and others. Anywhere that you need big power in small space.

A complete 386. 1 or 4 Mbytes DRAM. Dual serial ports and parallel port. Floppy and SCSI controllers. Plus solid state disk (EPROM or NovRAM), and an expanding list of MiniModule™ expansion modules. You can even add standard PC and AT form factor boards.

Priced right. Little Board/386 can jump-start you in 386-based, embedded-processor product development. Little Board/386 is shipping now. In quantity. And, we can deliver at prices that are more than competitive.

Answers. Now. Little Board/386 is the newest in our complete family of IBM PC and AT-compatible, single board systems. If you embed microcomputers in your products, call today for complete information on Little Boards, MiniModules and the name of your nearest Ampro representative. Worldwide.

Call Toll Free:

1-800-966-5200

AMPRO

SINGLE BOARD SYSTEMS

Ampro Computers, Inc., 1130 Mountain View/Alviso Rd., Sunnyvale, CA 94089
TEL: (408) 734-2800. FAX: (408) 734-2939. TLX: 4940302

All trade marks are the property of their respective owners.

CIRCLE NO. 91

To expand compressed images, you must know whether the compressed data includes padding or filling, and you must know the bit order of the compressed and raster data.

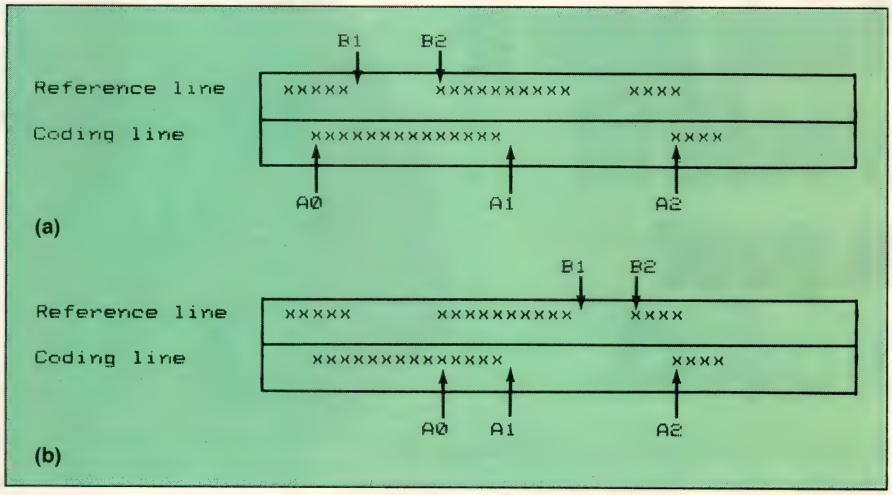


Fig 7—In cases where pointer A1 is to the left of B2 (a), *insert a pass code (0001) instead of one of the vertical codes from* ***(Fig 6b).*** *Then reposition the transition labels and move on to encode the next portion of the line* ***(b).***

Depending on how the changing pixels on the two lines relate, select one of seven types of "vertical" codes, a "pass" code, or a "horizontal" code.

A portion of a line qualifies for vertical encoding when pixel A1 is directly below B1, or within three pixels right or left of directly below. In this case, store the appropriate vertical code (**Fig 6b**), advance A0 to A1, and place the other labels accordingly (**Fig 6c**).

If pixel A1 is located to the right of B2 (**Fig 7**), store a pass code, advance A0 to the pixel below B2, and place the other pixels accordingly.

If a section of a line doesn't meet the criteria for vertical or pass encoding, store the horizontal code, followed by the G3-1D codes to express the run from A0 to A1, followed by the G3-1D codes to express the run from A1 to A2. Then move A0 to A2, and place the other labels accordingly (**Fig 8**).

Occasionally, pixels will qualify for more than one type of encoding. When that happens, pass takes precedence over vertical, which takes precedence over horizontal. Note that you should always splice each new code to what you have encoded before, without respecting byte boundaries.

Two-dimensional encoding offers an additional, little-used option: the K (error-immunity) factor. Designers may choose to embed 1-D lines at regular intervals amid the 2-D data. If a transmission error occurs, the receiver can use the 1-D line to regain sync. The value of K specifies the number of 1-D lines that will occur between each 1-D line. If K is not infinity, the compressed image begins with a line in 1-D codes, and straight 1-D lines appear every K lines thereafter.

One further standard, CCITT Group 4 compression, yields the greatest compression ratio. Group 4 is 2-D

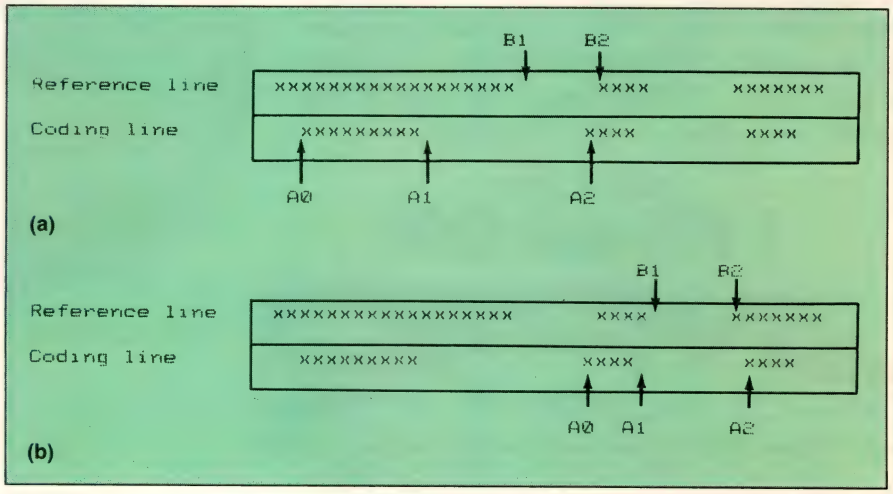


Fig 8—In many cases, neither vertical nor pass codes are applicable *to the disposition of bits on two successive lines. When A1 is to the left of B1 but not near it* ***(a),*** *insert code 001. Then encode both the run from A0 to A1 and the run from A1 to A2 with G3-1D substitution codes, finally repositioning the labels* ***(b).***

If you're not interested in second best results...



Sophia systems

Universal microprocessor/ microcontroller emulation systems.

Just a sampling of popular devices covered.

Intel Microprocessors	
8086/88/ C86/C88	10 MHz
80186/188/ C186/C188	16 MHz
80286	16 MHz
80386	25 MHz
80386SX/376	16 MHz

NEC Microprocessors	
V20/30	10 MHz
V40/50	10 MHz
V25	16 MHz
V33	16 MHz
V60	16 MHz



Why use anything but a first-class emulator? When it comes time to prove your design, the tools should be up to the task. And, that's what Sophia emulation systems are about.

Our SA98 is PC based and works with virtually all of the leading 'C' compilers, source level debuggers, and assemblers.

Bus-direct interfacing means code loads fast, and commands execute now. You'll have time to get the most out of your design.

The SA98 has trace and break points that set new standards in emulation debug. They are precise, powerful and easy to use.

Our SA98 is truly universal. From 8- to 32-bits, it can emulate hundreds of processors and controllers.

Call today for complete information on the SA98 and how to obtain a risk-free system evaluation. You'll be glad you did.

Sophia Systems and Technology
2450 El Camino Real
Suite 212
Palo Alto, CA 94306
Tel: 415 493-6700
Fax: 415 493-4648

Sophia Computer Systems, Ltd.
Alpha House
London Road, Bracknell
Berkshire RG12 2TJ England
Tel: 0344-862404
Fax: 0344-861374

Sophia Systems Co., Ltd.
Shinjuku NS Bldg. 8F
2-4-1 Nishishinjuku
Shinjuku-ku, Tokyo 163, Japan
Tel: (03) 348-7000
Fax: (03) 348-2446

© 1989 Sophia Systems
Sophia Systems is a registered trademark of Sophia Systems Company, Ltd.

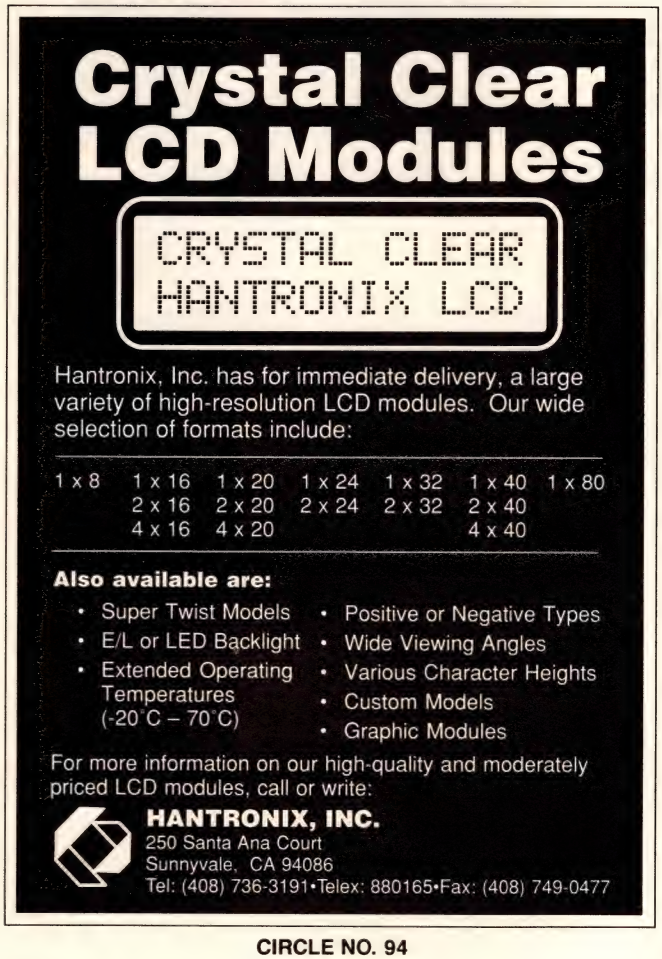
1-800-824-9294
OUTSIDE CALIFORNIA

1-800-824-6706
INSIDE CALIFORNIA

CIRCLE NO. 92



CIRCLE NO. 93



CIRCLE NO. 94

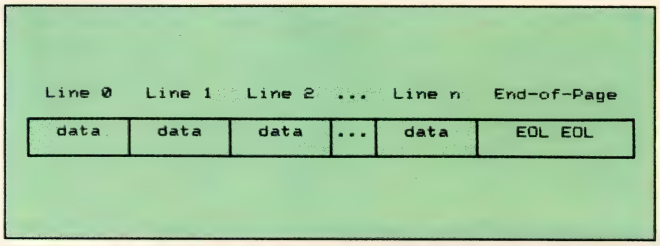


Fig 9—CCITT G4 encoding allows *no start-of-page code, no EOLs, no padding or filling, and no byte alignment to achieve the most compact compression possible.*

encoding with all the details fixed to yield the greatest compression (**Fig 9**). It allows no embedded, 1-D lines (K = infinity). The first reference line is an imaginary all-white line above the top of the image. No EOLs mark the start of the image or the end of lines. Group 4 has no padding and no filling and does not respect byte boundaries, except that the compressed image starts and ends on byte boundaries. An EOP mark, comprising two concatenated EOLs, follows immediately on the end of the compressed data, with padding to the end of the final byte. EDN

Reference

1. Fuchs, Peter M, "Compressing data conserves memory in bit-mapped displays," *EDN*, October 30, 1986, pg 173.

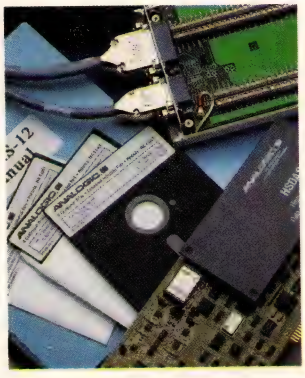
Author's biography

William C Warner is a consultant and operates his own firm, Real-Time Computer Applications, in Ann Arbor, MI. His work has included software and hardware design for digitized-image processing, instrumentation, and automation. His designs have gone into CAD workstations, PC interfaces, computerized machine tools, and programmable controllers. Will has a BS in Math from Michigan State University. In his spare time, he enjoys reading.

Article Interest Quotient (Circle One)
High 485 Medium 486 Low 487



16-bit PC/AT Data Acquisition from Analogic!



LSDAS-16 Brings New Price/ Performance Levels to PC Instrumentation

The new LSDAS-16 from Analogic sets new price/ performance standards for 16-bit multifunction data acquisition plug-in boards for the IBM PC/AT™ and compatibles, including:

- 16-bit 50 kHz A/D converter
- 16 analog inputs
- Shielded for less than 1 LSB of noise *in the PC*
- Programmable input modes and ranges
- Full analog triggering
- Dual deglitched DACs
- 32K-sample DAC RAM
- High speed DMA
- Menu-driven setup and data acquisition utilities
- C, Basic, FORTRAN, and Pascal libraries
- Third party support for Snapshot Storage Scope™, DADiSP™, and LabTech Notebook™
- Expansion multiplexers for up to 256 analog inputs
- Prices starting at $1,395 in unit quantities, with volume discounts available.

For applications from spectroscopy and chromatography to digital audio and speech analysis, step up to Analogic, the world leader in precision data conversion technology for more than 20 years.

For Applications Assistance, call or write David Wilson, Analogic Corporation, 360 Audubon Road, Wakefield, MA 01880
Telephone: (800) 446-8936, Telex: 466069, Fax: (617) 245-1274

IBM PC/AT is a trademark of International Business Machines Corp. Snapshot Storage Scope, DADiSP, and LabTech Notebook are trademarks of HEM Data Corp., DSP Development Corp., and Laboratory Technologies Corp., respectively. DADiSP software photo copyright DSP Development Corp.

ANALOGIC®
The World Resource for Precision Signal Technology

CIRCLE NO. 71



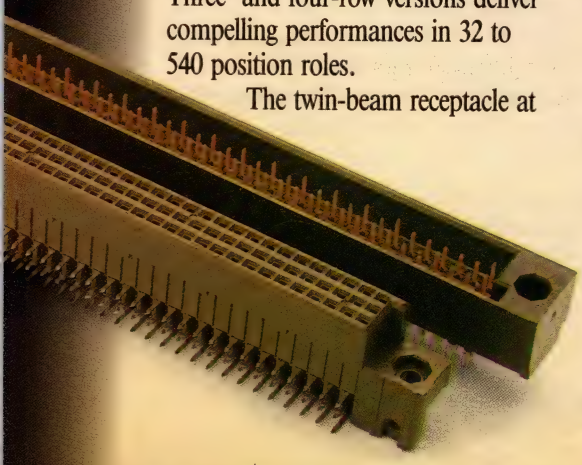
DOUBLE

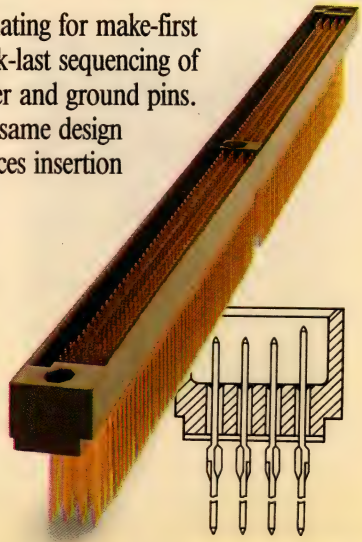
"... ★★★★ for

AMP TBC (Twin-Beam Contact) Connectors steal the show for high-density, high-pin-count affordability. Three- and four-row versions deliver compelling performances in 32 to 540 position roles.

The twin-beam receptacle at the heart of the TBC Connector represents the very best of AMP engineering—the greatest economy of material consistent with design excellence. It provides two-point contact (with gold-over-nickel plating), and the BeCu base assures high normal forces of 50 grams/contact (end of life minimum) for solid dependability.

There's more here than economy, though. Tightly controlled, short point-of-contact geometry allows two levels of mating for make-first break-last sequencing of power and ground pins. The same design reduces insertion



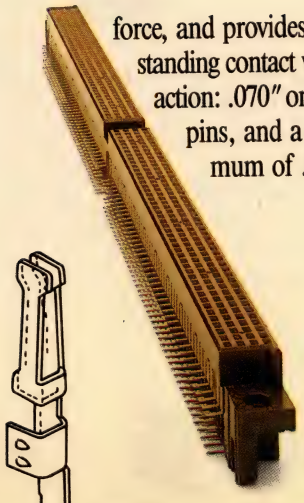


Two levels of sequenced mating allow "hot" connect/disconnect. Compliant pin option for solderless pcb insertion.

AMP and AMP-HDI are trademarks of AMP Incorporated.



cost reduction."



force, and provides outstanding contact wiping action: .070″ on short pins, and a minimum of .100″ on long. (Coming soon: TBC Plus Connectors, with six rows of contacts and three levels of sequencing.)

AMP TBC Connectors are fully polarized, with closed-entry design to eliminate stubbing, and they come in high-temp materials ready for vapor-phase and IR reflow soldering.

And TBC receptacle assemblies intermate with our popular AMP-HDI pin header assemblies, to give you immediate daughter card cost-reduction, without redesign.

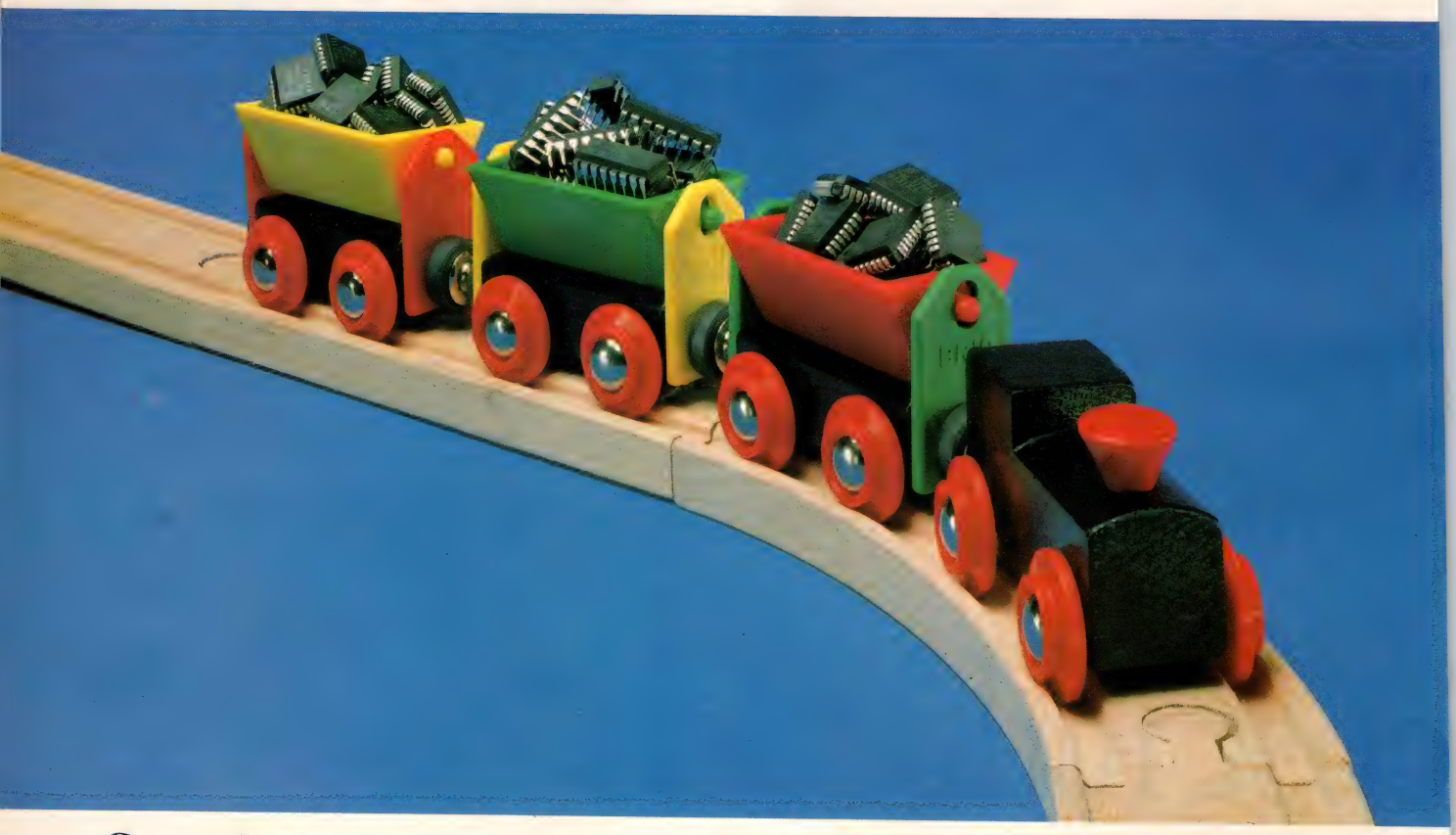
Call 1-800-522-6752 and ask about the AMP TBC Connector Series. AMP Incorporated, Harrisburg, PA 17105-3608.

Unique twin-beam receptacle delivers outstanding reliability in an affordable high-density connector.

AMP Interconnecting ideas

CIRCLE NO. 97

Stepper Motor Drivers on the right track.



Wooden train made by BRIO AB, Sweden. © BRIO AB, Sweden 1990. Protected by Patents and Regd. Trade Marks internationally.

Speed and power in surface mount or through-hole packages.

Switch to Ericsson and take advantage of the high-performance records we've been setting since 1982, when we introduced the first switched mode stepper motor driver IC.
Sit back and enjoy the speed and the power as you command more torque at higher speeds, thanks to our original constant-current chip architecture, now used – and copied – all over the world.
Jump on board and meet our team of single and dual drivers, with current ratings up to 1.8A, in low-cost Batwing DIP or the new Power PLCC package with heat-spreading lead frames.
And make a first class reservation with our microstepping chip set, with features to improve performance and cut hassle in your next robotic or instrumentation design.
Don't miss the Ericsson connection – send for our latest shortform product guide.



Our new Dual Channel Stepper Motor Driver PBL 3772 delivers more current at less power dissipation than two single channel devices.
Also available: the original PBL 3717 Chopper Driver and the pin-compatible PBL 3770A with 1.8A peak output, in DIP or power PLCC packages.
And the advanced chip set for micro-stepping, PBL 3771/PBM 3960.

ERICSSON

We're in the lead

Ericsson Components AB
S-164 81 Kista-Stockholm, Sweden.
Telephone +46 8 757 5000
Telefax +46 8 757 4776

CIRCLE NO. 98

Undersampling reduces data-acquisition costs for select applications

Undersampling, a form of intentional aliasing, may save you from using fast, expensive track-and-hold amplifiers and A/D converters. Meeting the technique's basic requirement—prior knowledge of the input signal—enables a converter operating at a sub-Nyquist sampling rate to derive useful information from the input.

Jeff Kirsten and Tarlton Fleming,
Maxim Integrated Products

In its familiar form, the Nyquist sampling theorem requires that an A/D converter sample the highest significant input frequency at least twice per cycle. Undersampling—a deliberate violation of this rule—is a useful option in certain carefully chosen applications such as synchronous demodulation, pulse-height measurement, and waveform digitization. The technique allows you to use an A/D converter that is slower and therefore less expensive than the converters necessary to perform Nyquist sampling.

Undersampling does comply with an extended or generalized version of the sampling theorem. This extended theorem states that you can reconstruct an input from sampled data if the input's frequency components lie entirely between adjacent integer multiples of one half the f_S sample rate (see **box**, "Spectral limiting enables undersampling"). An input spectrum violates this generalized sampling theorem if it includes or straddles one or more boundaries of the $f_S/2$-wide frequency bands.

The resulting alias frequencies usually distort the sampled output, making it virtually impossible to interpret, except in special cases where the input possesses a certain spectral order. Two examples of such order, to be discussed later, are the double sidebands that result from linear modulation and the extended spectra that result from undersampling a periodic waveform. To avoid unwanted alias frequencies in all cases, you must first evaluate the input spectral characteristics with respect to the converter's sampling rate.

Track and hold is crucial

The burden of speed and accuracy falls on the T/H (track-and-hold) amplifier rather than the A/D converter when undersampling wideband analog signals. The T/H amp must acquire fast-changing signals at uniform and precisely timed intervals, and it must present each sample to the A/D converter as a fixed input voltage. To do so, the T/H amp must have sufficient bandwidth and slewing to pass the input signal without introducing significant distortion. The A/D converter, on the other hand, has an easier task during undersampling operations. For applications in this article, the

The undersampling technique deliberately violates the Nyquist sampling theorem.

converter samples at a rate less than twice the highest input frequency of interest.

Undersampling allows a system to acquire narrowband signals whose frequencies are higher than one half the A/D converter's sample rate. Such applications arise in systems that digitize the intermediate frequency produced by a radio receiver (**Fig 1**).

Sampling the signal at f_S shifts the input frequency components in groups or bands to the sampled-data range of 0 to $f_S/2$. These $f_S/2$-Hz-wide bands are contiguous and extend to infinity. Each has a location $Nf_S/2$ to $(N+1)f_S/2$, where N equals zero or a positive inte-

Spectral limiting enables undersampling

Sampling converters measure a signal's amplitude at precise intervals and provide a digital output word corresponding to the amplitude of each sample. The digital word's sequence is only a partial description of the input signal; the sequence includes no information about variations between the samples.

You can often find a complete description, however, by applying suitable constraints to the input spectrum. The sampling theorem states that you can exactly recover a signal from sampled data if the input signal contains no components above half the sampling rate. In other words, spectral limiting allows sampled data to describe the input completely.

Consider the effect of sampling three distinct input frequencies—f_A, f_B, and f_C—at 100k samples/sec (**Fig Aa**). At 40 kHz, f_A is less than the 50-kHz Nyquist frequency. Components f_B and f_C at 90 kHz and 230 kHz, respectively, are greater than the Nyquist frequency. **Fig Ab** shows the spectrum after sampling. The location of component f_A is unchanged, but the sampling process has shifted f_B and f_C by multiples of the sample rate. Now, f_B's and f_C's sampled-data versions reside at 10 and 30 kHz, respectively. All three inputs now appear below ½ f_S in the sampled-data spectrum.

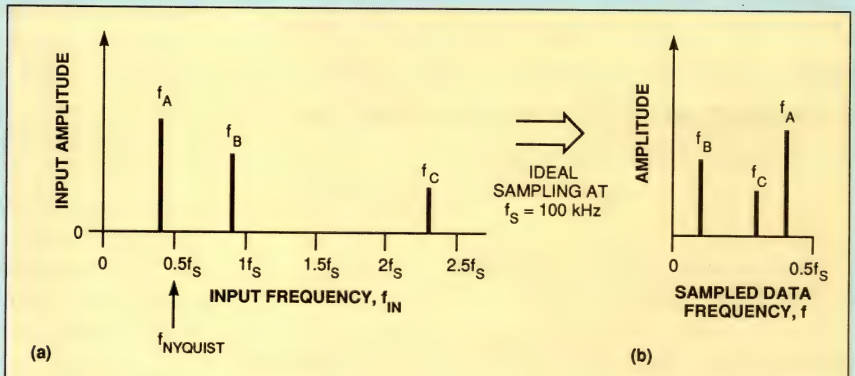
Sampling maps these input-signal components (**Fig Ac**) into the range below ½ f_S using the formula

$$f_{SAMPLED} = |f_{IN} - Mf_S|,$$

under the condition that $f_{SAMPLED} < ½\ f_S$.

This equation applies to an ideal sampling process—one with zero aperture time. The equation finds the multiple of f_S that is closest to f_{IN}, and subtracts it from f_{IN}. The absolute value of this difference is the sampled-data frequency, $f_{SAMPLED}$.

Using the equation above, you can't determine the input spectrum from sampled data alone because a given sampled-data spectrum can result from one of several input frequencies. Component f_C in **Fig Ab**, for example, could be the result of inputs at 30, 70, or 130 kHz as readily as from 230 kHz. Thus, to reconstruct an input signal, you must have some prior knowledge of the



LABEL	INPUT FREQUENCY	M	SIGN	SAMPLED DATA FREQUENCY
f_A	40 kHz (0.4 f_S)	0	+	|40 kHz – 0 kHz| = 40 kHz (0.4 f_S)
f_B	90 kHz (0.9 f_S)	1	–	|90 kHz – 100 kHz| = 10 kHz (0.1 f_S)
f_C	230 kHz (2.3 f_S)	2	+	|230 kHz – 200 kHz| = 30 kHz (0.3 f_S)

(c)

Fig A—Sampling three input frequencies, f_A, f_B, and f_C, *at a rate of f_S* ***(a)*** *creates a sampled-data spectrum* ***(b)*** *that repeats every $f_S/2$ Hz. The 0 to $f_S/2$ spectrum that results from the FFT thus includes an alias for every input frequency above $f_S/2$* ***(c)***.

ger. In **Fig 1**, $f_S = 100$k samples/sec, $f_{IN} = 510$ kHz, and $N = 10$. To exclude unwanted input frequencies, a bandpass filter restricts the converter's input to just one band: 500 to 550 kHz. Regardless of the converter's relatively low conversion rate, the resulting output data includes unwanted frequencies only to the extent of spectral leakage outside this filter's $5f_S$ to $5.5f_S$ passband.

You can measure the performance of this system by applying high-purity sine waves at the input and by performing an FFT on the output. A 510-kHz input, which equals $5f_S + 10$ kHz, produces a 10-kHz response

input spectrum, in addition to the sampled data.

Fig B, a plot of frequency ($f_{SAMPLED}$) vs frequency (f_{IN}), shows that the sampled-data frequency is cyclic in the range 0 to $f_S/2$. The spectrum of $f_{SAMPLED}$ actually extends to infinity, but repeats around multiples of f_S. The spectrum also exhibits mirror images on either side of each multiple. So all the information in $f_{SAMPLED}$ is available in any of the intervals $Nf_S/2$ to $(N+1)f_S/2$.

The input-frequency scale has an M value and a sign term associated with each $f_S/2$-wide interval, as **Fig B** displays. Input signals residing in any single interval, or band, will shift directly to the 0 to $f_S/2$ sampled-data band without loss of information or distortion caused by overlap. (Note that input spectral components that lie within any "+" interval will translate to the FFT output in the same sequential order; components within a "−" interval will translate in reverse order.)

In the bandlimited-IF application discussed in the main text, the 500- to 550-kHz IF signal fits neatly within the "+" band above $5f_S$ (**Fig B**). The IF signal therefore preserves its spectral order as it shifts—aliases—to the sampled-data band of 0 to 50 kHz. Knowing that the input originated in the band marked $M = 5$ and sign = "+" allows you to reconstruct the input exactly.

For the bandlimited-IF case, you simply translate the sampled-data spectrum upwards by 500 kHz. You can similarly reconstruct the spectrum of any "−" band by reversing the order of the sampled-data spectrum and making the appropriate frequency translation. Inputs confined to the 0 to $f_S/2$ band satisfy the requirements for Nyquist sampling as stated earlier. The bands above $f_S/2$ are called undersampled bands, although the same sampling principles apply for them as for Nyquist sampling. In either case a faster converter—one with a higher sampling rate—widens the bands and allows accurate sampling with less stringent bandlimiting of the input signal.

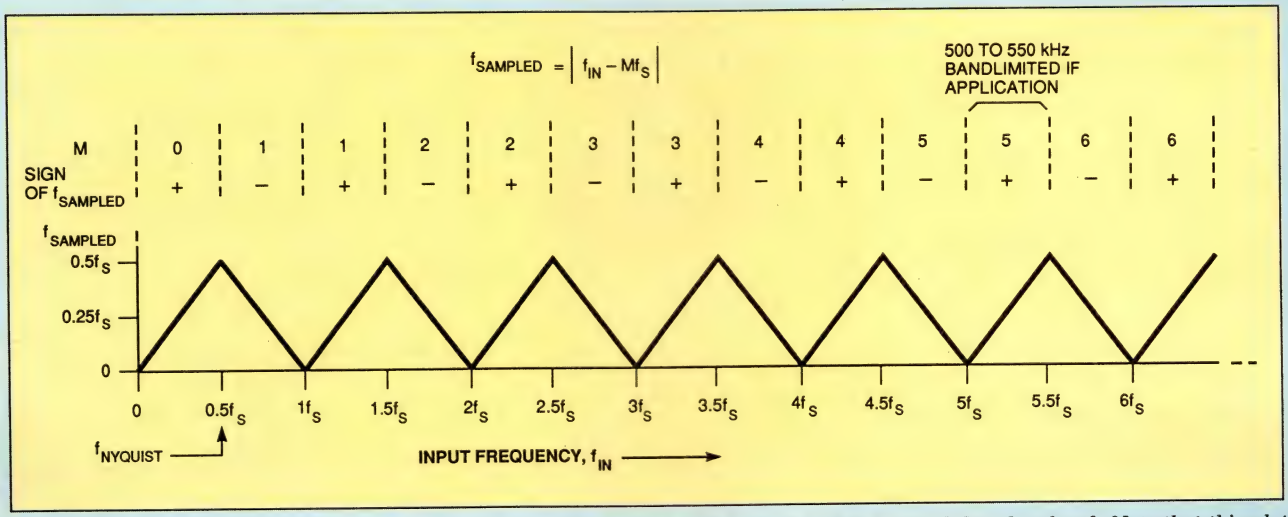


***Fig B—An input of arbitrary frequency** maps to a specific position within the 0 to $f_S/2$ sampled-data baseband. Note that this plot uses the convention that all information in $f_{SAMPLED}$ is contained in the interval 0 to $f_S/2$.*

In select applications, undersampling lets you use slower and thus cheaper ADCs.

in the FFT. Inputs at 490 kHz ($5f_S - 10$ kHz) or 590 kHz ($6f_S - 10$ kHz) could also produce a 10-kHz response, but the filter excludes those frequencies. Barring spectral leakage, the filter assures that each response in the FFT output derives from one and only one input frequency.

Fig 2a illustrates the FFT response for the MAX167 12-bit sampling converter operating on a pure 510-kHz input signal. The converter's internal T/H amp has a 6-MHz, predominantly single-pole roll-off, which reduces signal amplitudes in the 500- to 550-kHz band by no more than 0.04 dB. Frequency-dependent nonlinearities of the T/H amp produce second and third harmonics of 510 kHz that represent distortion levels of −60 dB (0.1%) and −70 dB (0.03%).

The device's A/D converter alone contributes no more error when processing the 500- to 550-kHz band than when processing the band from 0 to 50 kHz. The harmonics, which originate in the T/H amplifier's upper passband, disappear into the noise floor if you remove the bandpass filter and apply a pure 10-kHz input signal.

Besides harmonic distortion, T/H amps contribute phase noise as a result of aperture jitter that occurs in the sampling process. This phase noise originates both in the T/H amp and in the control signal applied to it. Wideband components of phase noise raise the FFT's overall noise floor; 1/f components cause a widening of the frequency lines, especially near their bases. Phase noise ultimately limits the attainable FFT resolution for larger sets of sampled data.

Fig 2b displays the frequency resolution available in **Fig 1**'s system by taking a 16,384-point FFT and expanding it around 510 kHz. Note that the 510-kHz input component is spread 67-Hz wide at a level 90 dB below the peak. About 4 Hz of this spreading is caused by the converter's 25 psec of aperture jitter, 14 Hz is caused by phase noise in the test setup's sine wave and clock-signal sources, and 49 Hz is due to the window function applied to the data prior to the FFT.

Except in specialized applications in which the sample record is synchronous with the input signal, window functions must precede an FFT. The window suppresses severe distortion due to spectral leakage, which is caused by the discontinuity between the end and the starting points of consecutive waveform records. Different window types impress different filter responses on the spectral components that pass through them.

The Blackman-Harris 4-term window, for example, is frequently used in digitizer testing. It widens spectral components in the 16,384-point FFT by 37 Hz at −90 dB. By comparison, the model DP7 window (Data Physics, San Jose, CA) used to generate the data in **Figs 2a** and **2b** widens the components by 49 Hz at −90 dB. Below that level, however, the DP7 window exhibits a lower widening rate. The DP7 window, suitable for use in testing high-resolution A/D converters, remains free of side lobes to −110 dB and is usable to −150 dB.

A sampling A/D converter can perform synchronous demodulation if the modulation sidebands are no wider

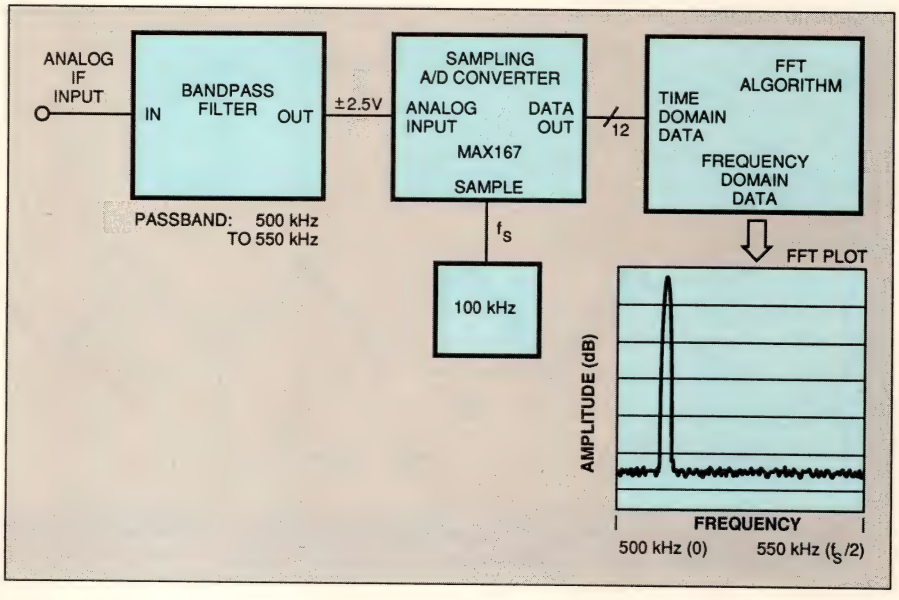


Fig 1—The undersampling process translates*—you might say intentionally aliases—the desired 500- to 550-kHz passband of this narrowband, high-frequency digitizing system to the 0 to $f_S/2$ FFT baseband. The input bandpass filter excludes unwanted alias frequencies.*

than half the sample rate. To ensure this condition, you need to limit the modulating signal's bandwidth or add a suitable filter ahead of the converter. Take the case of a 500- to 550-kHz upper sideband of a linearly modulated 500-kHz carrier. If the sample rate's fifth harmonic (500 kHz) closely matches the carrier in phase and frequency, then the converter's output will return a synchronously demodulated version of the signal. Applying the lower sideband of 450 to 500 kHz to the converter will produce the identical demodulated signal.

Applying both sidebands together—a double-sideband signal—produces the same demodulated output at twice the amplitude. Although this input violates the extended sampling theorem (because it straddles an integer multiple of $f_S/2$ at 500 kHz), the aliasing problems you might expect do not arise. As mirror images, the sidebands make identical contributions to the demodulated output. This property enables the sampling process to return the modulating signal to the baseband just as it does for single-sideband signals.

Measure pulse heights

Undersampling techniques also apply to the measurement of pulse heights, in the sense that only one sample of many is of interest—the one corresponding to maximum amplitude. Such measurements apply to the narrow, flat-topped pulses found in pulsed-RF generators and receivers, and in instruments that employ optical detectors. Pulse-height measurements also drive the leveling loops and output-power indicators of radar transmitters and other pulsed emitters. An 8-bit flash converter can do these jobs, but the combination of a fast T/H amp and a moderate-speed A/D converter can provide 12-bit-accurate measurements at comparable cost for pulses as narrow as 750 nsec (**Fig 3a**).

The circuit in **Fig 3a** lets you sample a single point that characterizes the pulse's amplitude. Applying the flat-topped waveshapes to the PULSE INPUT, you drive the pulse-measurement section with two externally generated signals: PULSE SYNC, which marks the rising edge of the pulse to be measured (**Fig 3b**); and an asynchronous, 1.5-MHz clock signal, which drives the converter.

The PULSE-SYNC signal triggers IC_4's one-shot, which in turn generates an acquisition-time interval sufficient for IC_1's T/H amp to acquire its input signal with specified accuracy. In this case, a 600-nsec interval allows IC_1's on-chip hold capacitor to charge within ½ LSB of the pulse amplitude. The T/H amp then switches to hold mode and the conversion begins. Because pulse inputs are asynchronous with the processor bus, the system includes a bus interface that allows the processor to detect and read current data before a new acquisition cycle begins. This interface, which consists of flip-flop IC_5 and bus drivers IC_6 and IC_7, also requires two external control signals. $\overline{\text{READ}}$

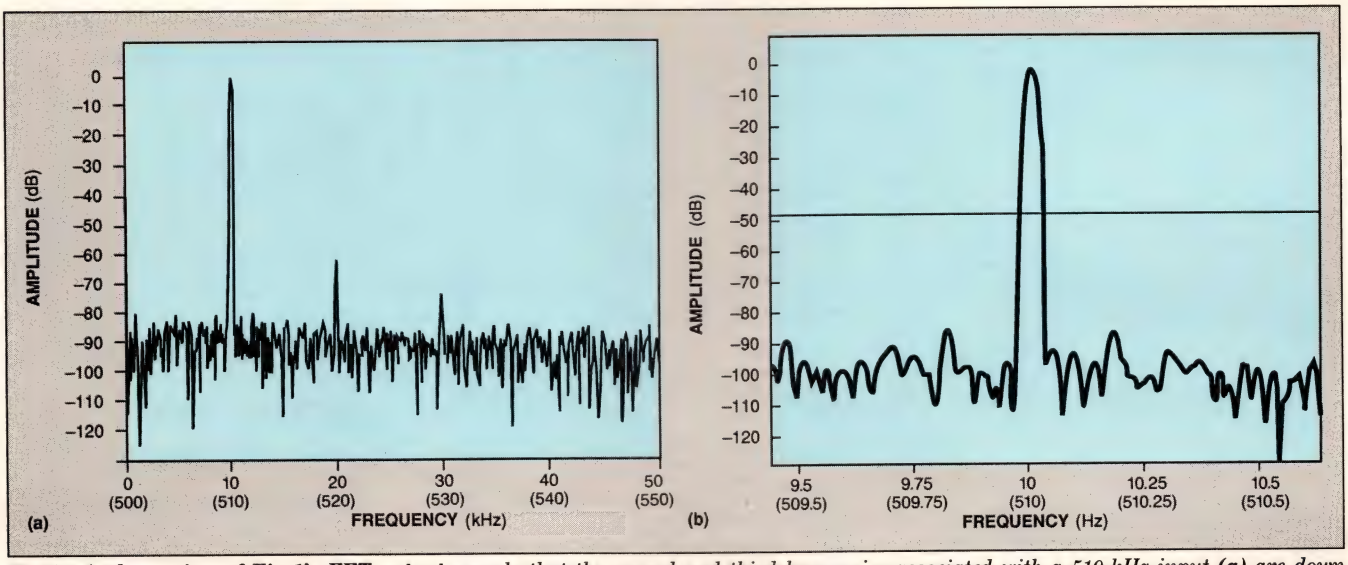


Fig 2—A closer view of Fig 1's FFT output *reveals that the second and third harmonics associated with a 510-kHz input* ***(a)*** *are down more than 60 and 70 dB, respectively. Note that the second harmonic (1020 kHz) appears in the FFT output as 20 kHz. Increasing the sample record from 2048 to 16,384 points* ***(b)*** *illustrates the frequency resolution—the width of the main signal in the FFT—for the DP7 sampling window.*

Knowledge of the input spectrum enables an ADC operating at a sub-Nyquist sampling rate to derive useful information from the input.

$\overline{\text{STATUS}}$ enables the output buffers, and $\overline{\text{READ DATA}}$ loads new data onto the bus. By clearing the internal CONVERSION-COMPLETE signal, $\overline{\text{READ DATA}}$ also arms the circuit for the next PULSE-SYNC trigger.

The external 1.5-MHz clock is asynchronous with both the bus and the arriving pulses. Consequently, when clock edges coincide closely with the track-to-hold command, some noise energy usually couples to the analog channel via parasitic paths in the IC and in the external printed circuit. The resulting offset error, whose amplitude varies with clock phase over a range of several LSBs, appears as noise. IC_2 minimizes this offset noise by blocking the clock signal during the track-to-hold transition. IC_3 then re-enables the clock during the next full cycle, following a delay of at least half a clock cycle.

Ideally, an output sample represents pulse height at the instant the converter switches from track to hold. Finite resistance in the sampling switch, however, contributes an RC delay that causes hold-capacitor voltage to lag the input signal. The sampling converters of **Fig 1** and **Fig 3a** thus exhibit a step response that closely resembles a single RC-network exponential. This time constant, about 24 nsec for the MAX163, largely determines the converter's −3-dB bandwidth: $f_{-3\ dB} = \frac{1}{2\pi\tau}$, where $\tau = RC$. The settling time depends on additional and larger time constants. The minimum

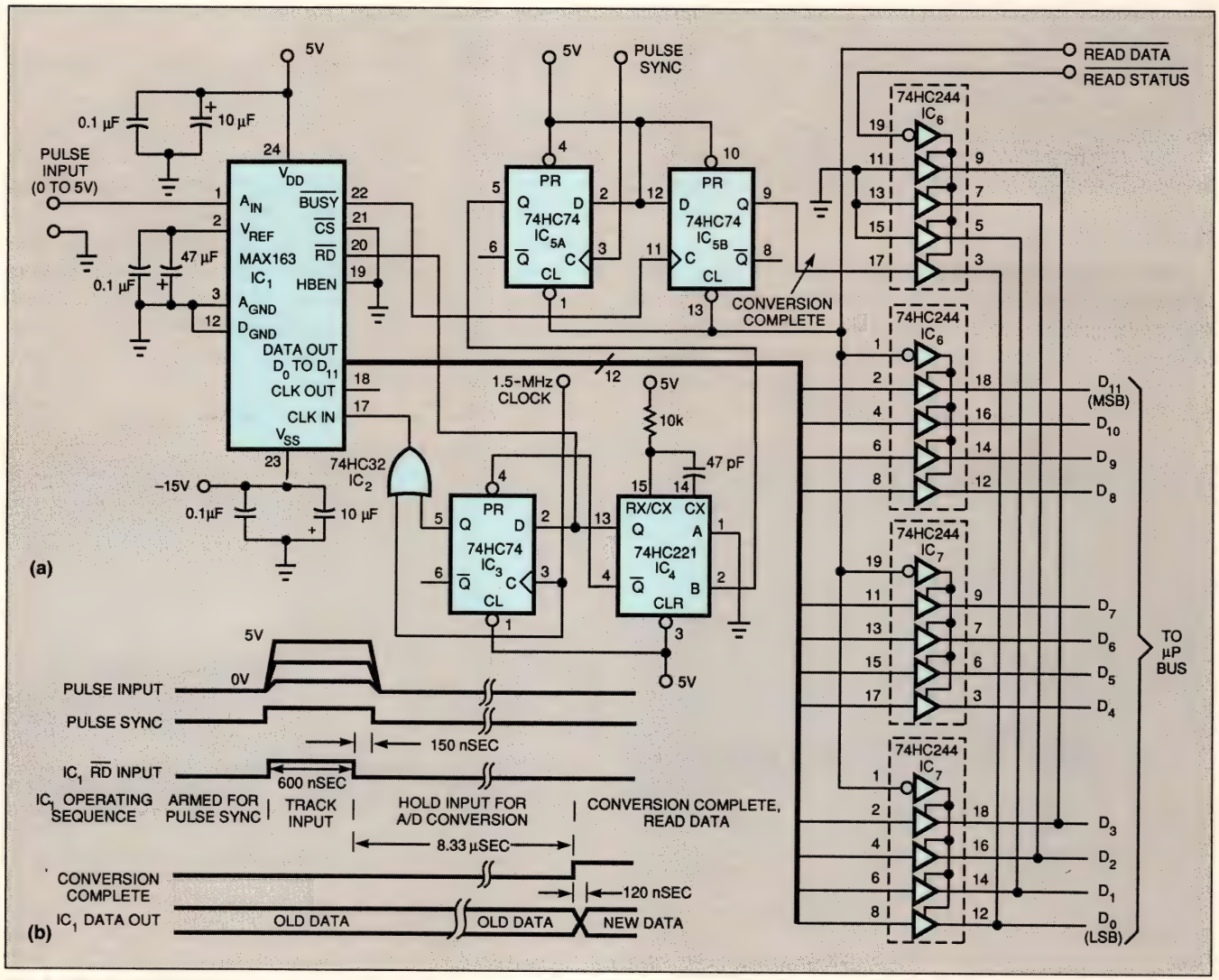
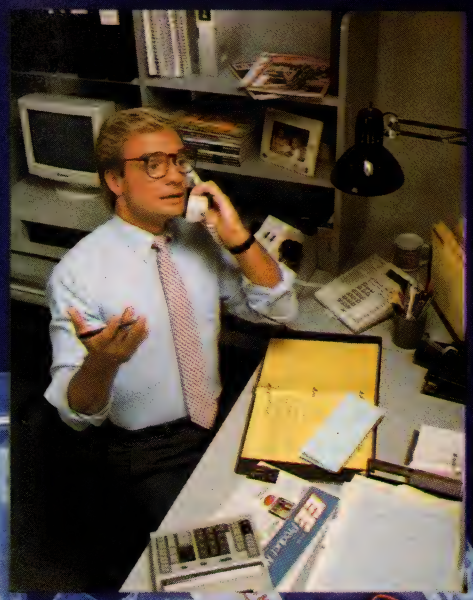


Fig 3—This pulse-height measurement circuit (a) *adds delay to the externally generated PULSE SYNC signal to position the sampling point on the waveform* ***(b).***

"But there's not enough time to order all the special panel indicators we need!

Now what?!"





All indications are Dialight.

The customer was an electronics firm known for his highly specialized, custom equipment. He had the proprietary technology; his problem was getting a wide range of custom indicators to match. And his newest product was due for immediate release. That's when he called Dialight.

As the leader with over half a century of experience in every type of indicator light, for Dialight solving problems is standard operating procedure. We provided incandescent, neon and LED panel indicators in every shape, size and color; each with performance properties that highlighted his proprietary systems. We let him limit quantity, but as always, delivered limitless quality. And we did it at better prices than he had been getting for his quantity orders.

Offering a vast assortment of panel indicators right off the shelf isn't all that makes Dialight right. Over the years customers have asked us to make them with integral resistors, light shielded, RFI/EMI shielded, front mounted, rear mounted, relampable, oil-tight, water-tight, MIL-spec'ed, just about any way you can imagine and we haven't been stumped yet!

So, the next time you have a need for indicators, be they incandescents, neons or LEDs, either customized or from our incredible off-the-shelf selection, remember that no one has more solutions than Dialight.

DIALIGHT CORPORATION
A Cambridge Electronic Industries Co.
1913 Atlantic Avenue, Manasquan, NJ 08736 201-223-9400

When undersampling wideband analog signals, the burden of speed and accuracy falls on the T/H amplifier rather than the ADC.

acquisition time (settling time) necessary to achieve 8-, 10-, or 12-bit accuracy is approximately 200, 350, or 500 nsec, respectively.

In the pulse-height application, a selected feature of the input waveshape—the rising edge of the pulse for example—triggers a fixed delay preceding the sampling instant. However, if you add a small increment to this delay after each conversion, you can digitize a periodic signal whose bandwidth exceeds the converter's sample rate. Again, the benefit is the cost savings realized by using a slower A/D converter. The converter's action is similar to that in a sampling oscilloscope, in which a fast S/H amplifier "walks" its sampling point along a wide-bandwidth waveshape.

A test circuit (**Fig 4a**) demonstrates this undersampling technique by applying the recurring stimulus f_{STIM} to a network and digitizing the response. By controlling f_{STIM}, the circuit is able to synchronize the signal to be measured to the 20-MHz oscillator. The frequency of f_{STIM} must be low enough to allow each network response to decay nearly to zero before the next stimulus arrives. IC_1, a combination A/D converter and high-speed, 6-MHz T/H amp, then samples the network response at apparent 50-nsec intervals.

The circuit's 20-MHz oscillator drives a 256-count divider, which in turn drives the sampling converter's SAMPLE input. The oscillator also drives a 255-count divider, whose output triggers the STIMULUS signal. The sample command and the stimulus square wave occur nearly at the same rate, but the sample command advances one 50-nsec count with each repetition of the stimulus (**Fig 4b**).

The converter output represents signal amplitudes at 50-nsec intervals along the input waveform. Each successive group of 255 consecutive points is identical and represents a complete, one-cycle record of the input signal. Each such record has a duration of 12.75 μsec in real time. By producing only one sample per input cycle, the A/D converter requires only 3.264 msec to complete a record. The FRAMING SIGNAL denotes each record with a pulse that occurs each time the SAMPLE and STIMULUS signals are in phase. Thus, the converter's output data defines an expanded time scale with respect to that of the input samples.

Fig 5 illustrates this circuit's action in the frequency (**b**) domain. The input spectrum consists of a dc component and harmonic multiples of f_{STIM}. By setting f_{STIM} slightly higher than the sample rate, you assure for each successive f_S-wide band an additional frequency difference—offset—between the harmonics of f_{STIM} and corresponding multiples of the sample rate (**Fig 5a**). The sampling process shifts each of the f_{STIM} harmonics to unique, nonoverlapping locations in the sampled-data baseband (**Fig 5b**), where the harmonics comprise

Track/hold, sample/hold, or sampling converter?

The terms track/hold and sample/hold appear almost interchangeably in data-acquisition literature. Both amplifier types store a signal's amplitude on a capacitor, and both have an analog switch that isolates the capacitor. The difference between them lies in the closed-switch interval. Corresponding to the sample or the track mode, this interval is short and fixed in a S/H amp but of arbitrary length in a T/H amp.

Drive circuits for the switch provide a practical distinction between the devices. S/H amps, for instance, are usually high-speed signal blocks used primarily in RF applications. The amp's edge-sensitive control input triggers an acquisition interval that is followed rapidly by an automatic return to the hold mode. T/H amps, on the other hand, have a level-sensitive input that allows a control bit to shift the device between track and hold modes as the application requires. Thus, T/H amps can sample but S/H amps can't track. The term track/hold is correct for most of the devices used to deglitch D/A converters or condition the input signals for A/D converters.

An A/D converter can, for a given level of accuracy and resolution, digitize much higher frequencies when preceded by a T/H amp or a S/H amp. Some manufacturers combine the convert and hold functions as a sampling converter, and fabricate it in a single IC or as a multichip device in a single package. These products simplify design by eliminating the need for an explicit accounting of track/hold errors. As a further bonus, the data sheets usually specify ac performance in addition to the dc parameters normally associated with an A/D converter.

HARDNOSED.

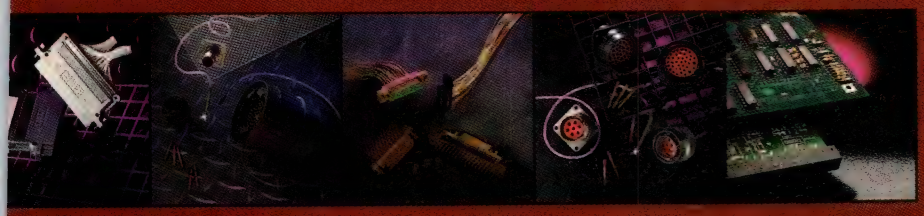
Cinch™ Military/Aerospace Division is a hardnosed bunch when it comes to designers' needs. We know their customers and applications demand high-quality, cost efficient interconnection systems.

Our response is a lineup of quality products ranging from our microminiature *Dura-Con™* line qualified to *MIL-C-83513*, to the *Vibra-Lok™ MIL-C-38999 Series IV*, to our *MIL-C-26500* cylindricals and full cable assembly capabilities.

It's no wonder Cinch connectors increasingly are the choice of engineers in aircraft, engines, missiles, and avionics. Our leading-edge work in market-driven technologies like *CIN•APSE™* high density contact systems, *fiber optic terminus* that provide EMI protection, and *modular rectangular air craft systems* assure a leadership role into the future.

And we don't stop there. To help our customers grow to meet global demands, we developed a world-wide network to provide products, services, and technical capabilities wherever, whenever they're needed.

Sure we're tough. But for a reason. And that's to make it easier for you to meet your demanding design goals. Just call (708) 981-6010.



CINCH

Solutions That Connect.

Military/Aerospace Division
1500 Morse Avenue
Elk Grove Village, IL 60007
FAX: (708) 981-6371

A Division of Labinal Components and Systems, Inc.

Note: Cinch, Dura-Con, Vibra-Lok, and CIN•APSE are trademarks of Labinal Components & Systems, Inc.

© 1990 Labinal Components & Systems, Inc.

CIRCLE NO. 100

Synchronous demodulation, pulse-height measurements, and waveform digitization can benefit from undersampling.

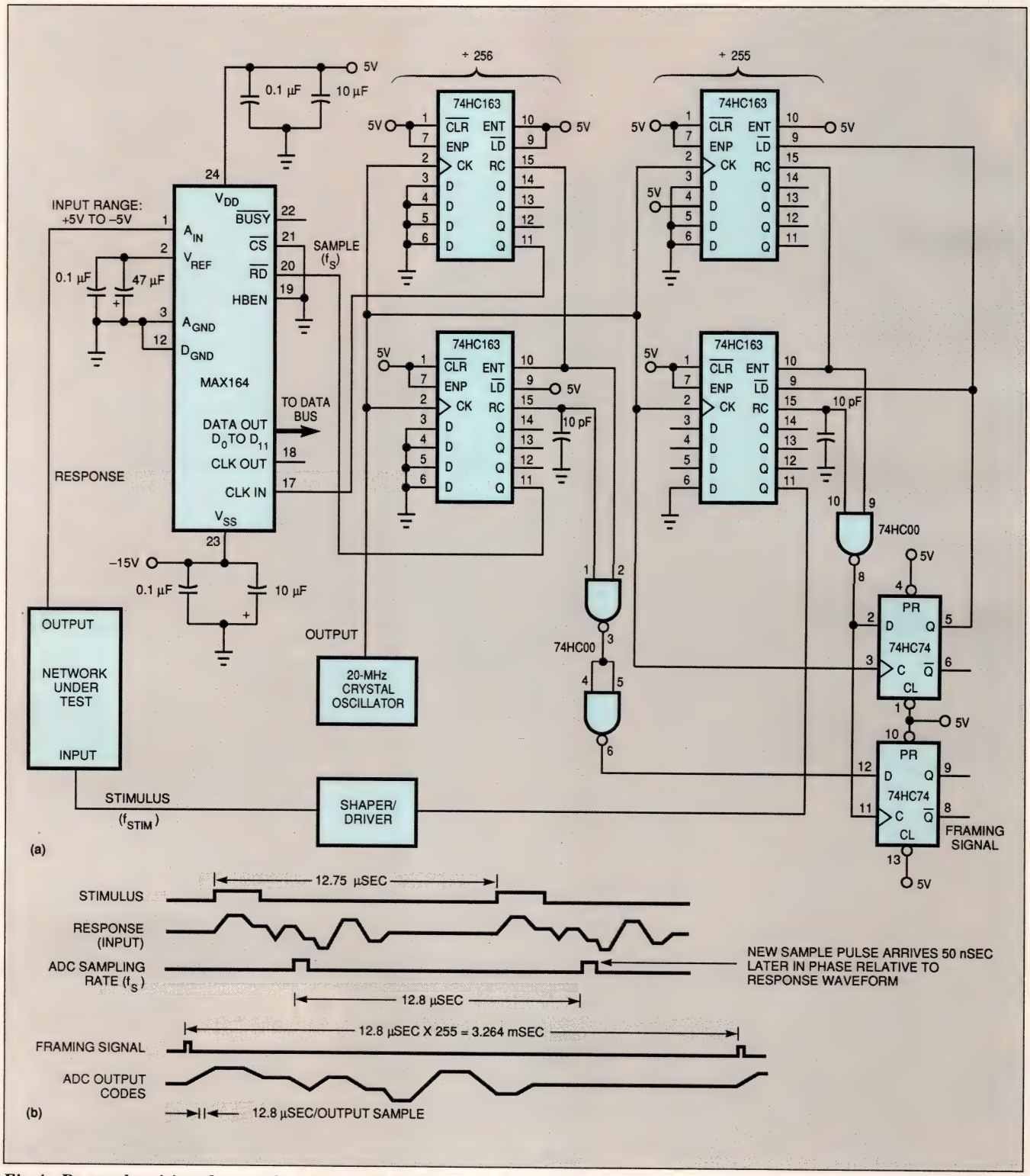


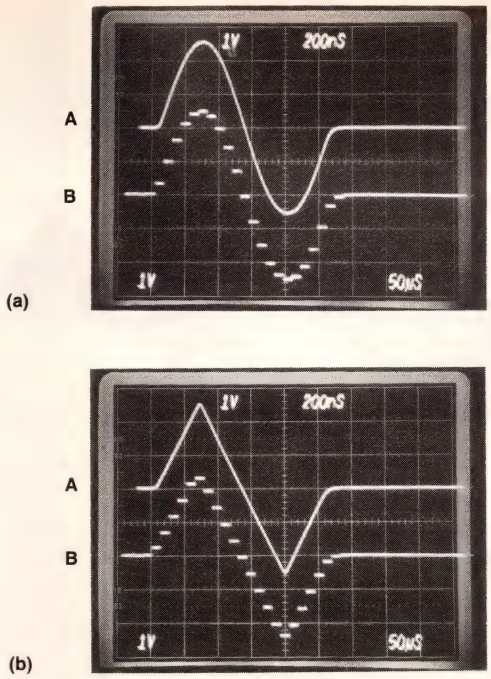
Fig 4—By synchronizing the sampling time with the stimulus signal, *the system in* ***a*** *employs undersampling techniques to digitize wideband periodic signals. The sampling rate, slightly less than the input signal's repetition rate* ***(b)****, provides an effective sampling interval of 50 nsec.*

a frequency-scaled replica of the input spectrum.

Figs 6a and **6b** illustrate **Fig 4**'s output using a function generator as the network under test. The generator produces a single sine-wave or triangle-wave cycle for each stimulus trigger. In each photo, the top trace displays the input signal and the lower trace is the reconstructed output codes from the A/D converter. Twenty-one samples from the waveform digitizer represent one cycle of the input signal, spanning approximately 1 μsec in real time.

The 50-nsec equivalent-sampling interval in this application provides an effective sampling rate of 20M samples/sec for periodic signals. According to the sampling theorem, the circuit can process input bandwidths to 10 MHz without aliasing. Moreover, the circuit response is virtually free of slew-rate effects, thanks to small- and large-signal bandwidths that match within 0.3 dB over a range of dc to 20 MHz.

As a second example of wideband waveform digitizing, consider the use of undersampling in capturing a still frame of video data. Assuming a picture bandwidth of 6 MHz, the Nyquist sampling rate must equal at least 12M samples/sec. The 100k-sample/sec converter must therefore sample and convert every 120th pixel on each pass. Each video frame, which occurs at a rate of 30/sec in the US and Japan, will begin one pixel later if you adjust the sample rate slightly below 100k samples/sec. The result will be a conversion of pixels 1, 121, 241, and so on in the first frame; 2, 122, 242, and so on in the second frame; and so on for four seconds—120 frames—until the entire image of 400k pixels is completed. Obviously the picture must not move, just as the undersampled signal must be periodic.



TRACE	HORIZONTAL	VERTICAL
A	200 ηSEC/DIV	IV/DIV
B	50 μSEC/DIV	IV/BIV

***Fig 6—These photos illustrate the results** of **Fig 4**'s equivalent-time-sampling technique. The sine-wave generator in **a** and the triangle-wave generator in **b** produce one input cycle per stimulus. The bottom traces display a DAC's reconstruction of the sampled signal. Note that each reconstruction step represents a complete pass of the input signal, resulting in different time scales for traces A and B.*

In each preceding example, knowledge of the input spectrum enabled an A/D converter operating at a sub-Nyquist sampling rate to derive useful information from the input signal. Inputs confined to a single band between integer half-multiples of the sample rate—as in the narrowband-IF system and the synchronous demodulator with a single-sideband input—always satisfy the generalized sampling theorem.

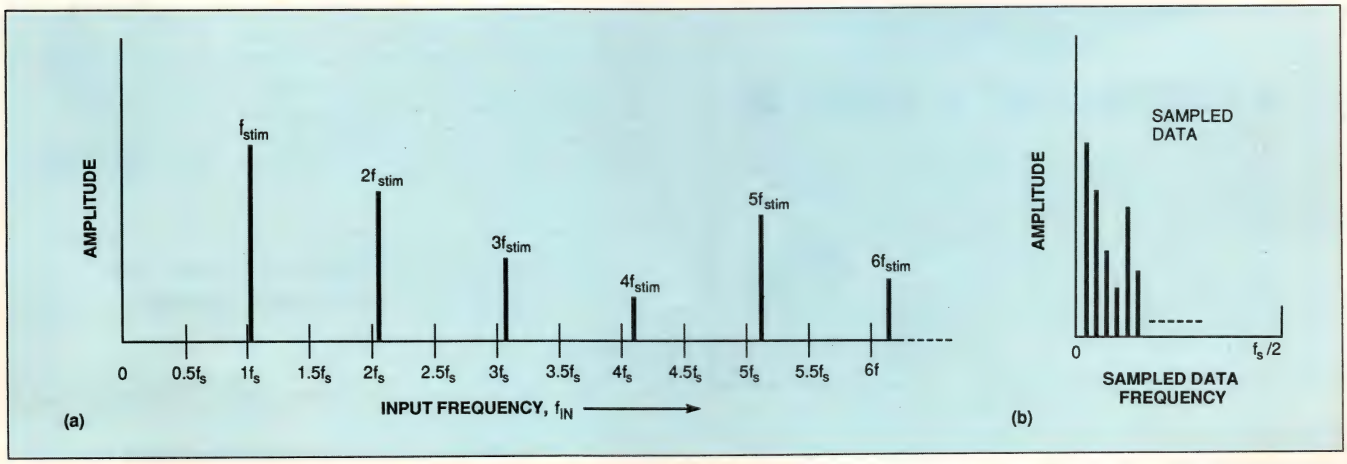


***Fig 5—The periodic signal f_{STIM} recurs** at a slightly higher rate than f_S **(a)**. The sampling process shifts all the signals to nonoverlapping lines in the FFT baseband **(b)**.*



Engineering

CMS can offer you more engineering experience in custom molded cable assemblies than any other manufacturer. We engineered the first custom Molded-On® cable assembly 40 years ago. Our complete facilities provide in-house design and construction of proprietary tools and dies to the final manufacturing of 100% tested finished goods. Call or write Component Manufacturing Service, Inc.; One Component Park, West Bridgewater, MA 02379. Tel. (508) 580-0111.

CMS is the Molded-On® connector company.

CIRCLE NO. 101



A SLEEPING GIANT IS WAKING UP.

GS BATTERY (JAPAN STORAGE BATTERY CO., LTD.) supplies energy sources worldwide for thousands of electronics, security, computer and communications needs. Until recently, we've been content to sell our products through private marketing channels. Now, GS BATTERY—"THE QUIET GIANT"—is waking up and wants you to get to know us better.

Our wide range of PORTALAC sealed lead acid batteries provides state-of-the-art performance for a myriad of applications. Position insensitive, they may be used in series or in parallel for maximum design flexibility. GS BATTERIES feature the highest power-to-volume ratio available in the industry. Their maintenance-free design, low self-discharge rate, and high energy density are some of the reasons why more of today's cost-conscious, performance-oriented engineers specify GS BATTERIES for their most demanding applications.

For detailed specifications, call, write or fax us today and tell us about your requirements. Find out how a quiet giant called GS BATTERY can go to work for you.

GS
SPARKING GENERATIONS OF NEW TECHNOLOGY

GS BATTERY (USA), INC.
17253 Chestnut Street
City of Industry, CA 91748
Tel: (818) 964-8348 Fax: (714) 598-5872

CIRCLE NO. 115

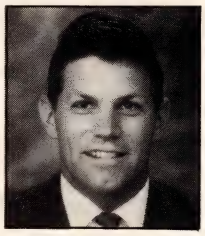
Inputs that occupy more than one of the $f_S/2$-wide bands normally produce unwanted alias frequencies that result in output distortion. In a few special cases, however, the spectral components of such an input possess order that assures an undistorted output. Such order is present, for instance, in double-sideband signals.

Spectral ordering is also present in the waveform-digitizing application, in which as many as 128 input-frequency components, each in a different band, contribute to a single, undistorted output. In this case, the system provides the order by using the stimulus rate to make the input signal periodic. EDN

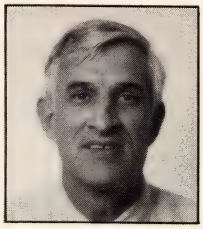
Acknowledgment

The authors wish to recognize the contributions and recommendations of many individuals at Maxim, especially Charlie Allen, Bruce Furman, Greg Schaffer, and Dave Watson.

Authors' biographies



Jeff Kirsten is a design engineer for Maxim Integrated Products (Sunnyvale, CA). He's been with the company for 1½ years and designs D/A and A/D converters. Jeff is a graduate of California State Polytechnic University—Pomona, from which he earned his BSEE. In his spare time, Jeff enjoys hang gliding, backpacking, and traveling abroad.



Tarlton Fleming has been a writer/editor for Maxim since joining the company a year ago. Besides writing technical articles and editing those written by his colleagues, Tarlton also edits the company's quarterly Engineering Journal. *Tarlton received his BSEE from the University of California—Berkeley.*

Article Interest Quotient (Circle One)
High 497 Medium 498 Low 499

For more information on TDK's insert circle 200 →

Combining analog simulation techniques optimizes designs

Deterministic simulation helps refine your circuit design; statistical simulation can help improve the manufacturing yield. Just be sure you understand how the parameter values of your simulation models are determined. A discrete device and a monolithic device use the same model, but for accurate simulation, their parametric values will often differ.

Lester S Sanders, *Harris Corp*

When you're designing analog circuits, you may be using only discrete components or creating ASICs to reduce board size and improve performance. In either case, you can use Spice or a derivative simulator to refine the circuit before committing it to silicon. The two main types of simulation are deterministic and statistical. Both have several subtypes, which elicit different types of information about a circuit. By combining simulation techniques, you can optimize your circuit design.

Whichever type of simulation you use, the values of the Spice model parameters must accurately model the devices' actual performance; otherwise, the simulator's predictions will be worthless. The model of a given circuit will be the same whether you use discrete components or design an analog ASIC, but the parametric values will usually differ. The parametric values will also differ depending on which type of simulation you use. You should know how the CAE vendor arrives at models' parametric values because most analog-CAE tool suppliers focus on pc-board design rather than ASIC design.

Simulations that only run once are deterministic. Multiple-run simulations, like those for Monte Carlo analysis, are statistical simulations.

Deterministic simulation can be nominal, worst case, or tracking. In nominal simulation, you use mean values for model parameters. Worst-case simulation requires you to use worst-case parameter values. Tracking simulations consider the correlation among device parameters. In the tracking mode, you assign values to a subset of the model parameters, and the remaining parameters vary according to their correlation coefficients. Any unassigned and uncorrelated parameters assume their mean values.

Statistical simulation also has three subtypes. These statistical modes are tracking, mismatch, and tracking/mismatch. With statistical simulation, model parameters are defined by the means, standard deviations, and correlation coefficients. At each iteration in the simulation, the simulator assigns new values to the parameter set. Mismatch simulation gives two identical devices parameter values that differ only slightly from one another. The remaining devices use nominal values. Mismatch mode investigates the dc characteristics of the device. In contrast to mismatch, tracking simulation uses the same set of model parameter values for different instances of the same device. Tracking/mis-

Because parameter variations often correlate, you might be able to use the results of one test to predict the results of another.

match mode combines the characteristics of both tracking and mismatch simulation.

Some designers concentrate on worst-case simulation because they think it provides the widest design margin. They reason that if device parameters assume worst-case values and the device still meets specifications, then the design will meet or exceed the output requirements. This reasoning can lead to an inefficient design.

Worst-case simulation uses worst-case operating conditions and worst-case device parameters. For most circuit output parameters, these conditions are the highest operating temperature and the lowest supply voltage. However, a single set of worst-case conditions for all parameters never exists. For example, supply current improves (decreases) as the temperature increases, but operating frequency decreases with increasing temperature. Thus, worst-case simulation doesn't always provide the widest design margin. Also, this type of deterministic simulation often predicts circuit output that is significantly worse than measured worst-case values.

Worst-case simulation's poor predictive ability stems from device correlation. Device parameters often correlate, so they cannot simultaneously have worst-case values. A nonzero correlation between model parameters limits the values that dependent parameters can assume. Since worst-case simulation assumes no correlation, the simulator can assign values to device parameters that are incompatible with manufacturing-process variances. To design conservatively using a large design margin, use the deterministic tracking mode instead. This mode lets you focus on device parameters that affect specific output parameters while accounting for correlation.

In analog-ASIC design, the physical layout influences electrical design. Layout-dependent parasitics can significantly affect the circuit output parameters. To avoid wasting time on a faulty design, check the effects of the physical design after a preliminary electrical design. In a good design flow, you iterate electrical and physical design while attempting to converge on the design requirements. Use deterministic simulation (which runs faster than statistical simulation) to verify the initial design.

Whether you use deterministic or statistical simulation, you can evaluate the effect of design alternatives on circuit parameters. You can use sensitivity analysis with deterministic simulation to uncover the effect of parametric variances on an output parameter. In sensitivity analysis, you modify one parameter value while keeping the others at nominal values. You then run a simulation to determine the sensitivity of an output parameter to the modified device parameter. Suppose the open-loop voltage gain of an op amp, A_{VOL}, is too low. To determine the cause, run a sensitivity analysis to test A_{VOL}'s sensitivity to each device in the circuit. After testing each device, you may be able to trace the problem to the β in an input device.

Yield measures the percentage of ICs meeting a specified set of circuit parameters. Statistical simulation can predict manufacturing yields because it takes into account manufacturing-process variations over a number of wafer lots. Deterministic simulation isn't very useful as a yield predictor because it runs only one simulation. As a result, yield is either 0 or 100% because the circuit either meets the specification or it doesn't.

The manufacturing yield projections of an analog ASIC contain two components—functional yield and parametric yield. Functional yield is the percentage of the dies on a wafer that perform the required function. Parametric yield is the percentage of functional dies that meet the specification. First, test all dies on the wafer for function. Then, test the functional dies to the specification. Using this test sequence, the total yield is the product of the functional and parametric yields. Statistical simulation predicts parametric yield but not functional yield.

Statistical simulation lets you use yield to evaluate design alternatives. You may need to relax some specifications to increase yield, but you can often tighten specifications without affecting yield. Deterministic simulation doesn't give you the range of variations of a parameter, and changing specifications based on a wide design margin without knowing the output-parameter distribution is risky.

Consider a specific type of statistical simulation: Monte Carlo analysis. For this analysis, the simulator varies the model parameter values through a number of iterations of the simulation. In a Monte Carlo simulation, each iteration emulates a wafer-lot manufacturing run where variations in the manufacturing process cause device parameters to fluctuate. Generating parameter values is not straightforward—you need to understand how values are built into your simulator.

To run a Monte Carlo simulation, specify the number of iterations to run, type of analysis (such as dc, ac, transient, sensitivity, or noise), the output parameters you want to evaluate, and the number of standard

deviations about the mean that the parameter can vary. CAE vendors use a .MODEL statement to change the model parameter's values from their default values to an expression. The Monte Carlo routines loop through the circuit simulations and store the output parameters in arrays. All Monte Carlo routines generate random values for device parameters. Because most of the routines do not correctly model parameter correlation on an ASIC, the values used by the simulator are not accurate for ASICs.

A random-number generator within the simulator varies the model parameters to simulate random manufacturing variations. In a simplistic scheme, a random-number generator selects a random number between −1 and +1, and the simulator calculates the model-parameter value from the following expression:

Model_parameter_value = Nominal_value + Absolute tolerance × Random_number × Nominal_value.

This method is a holdover from CAE tools that support discrete-component design. These models specify absolute tolerances. When the simulator calculates model-parameter values this way, the values in each iteration are uniformly distributed throughout the tolerance range. During actual manufacturing, however, a parameter is more likely to approach its mean value, so a uniform distribution isn't accurate. To better approximate reality, most analog CAE vendors let you define the values of the model parameters using a probability-density function.

Manufacturing-process variations can have independent or correlated effects on device parameters. When a process variance only affects a single device parameter, that parameter is independent of the other device parameters. When a process variance affects more than one device parameter, the affected parameters are correlated. For example, diffusing a higher concentration of impurities into the base region of a transistor can affect the base transit time (base transit time is inversely related to unity gain frequency), the current gain, β_f, and the value of the base-diffused resistor.

To achieve accurate circuit simulation, the model-parameter values for ICs should be statistically defined. Probability-density functions include the mean and standard deviation of each model parameter. To determine correlation coefficients, you'll need a significant number of process and device simulations and a large amount of test-circuit data. Simulators with sophisticated Monte Carlo routines use multilevel random-number generators because independent process disturbances affect model parameters differently. The effects differ depending on whether the devices are on the same IC, wafer, or lot.

In contrast to discrete components, devices on an

Simulation language provides flexibility

Sweeps, sensitivity analysis, and Monte Carlo analysis are vital circuit-analysis tools, but you might want to modify a device's parameters in a way different from that in which these tools change them. Sensitivity analysis modifies device parameters in a predefined manner; in Monte Carlo analysis, device parameters change randomly. You might also want to control the output parameters that the simulator provides. Sensitivity analysis provides the output of a single circuit parameter. Parameter sweeps provide one or two circuit-output parameters.

Simulation Language with Integrated Circuit Emphasis (Slice) is a high-level language that uses Spice as a core simulator and lets you modify device parameters in any manner. Using loops and arrays, you can make a series of design modifications and run the design in batch mode. When you've got to run numerous routines, batch mode requires less computer input time than does interactive mode.

Analog circuit design often involves a series of tradeoffs among ac, dc, and transient output specifications. Design modifications that improve one circuit parameter often degrade another. Slice lets you specify the output data that you want with a single command. This data could include a complete list of ac, dc, and transient parameters, and you could write this command file early in the design phase. As you make design changes, the simulator can monitor the appropriate set of output data without your having to rewrite the output tests.

Statistical simulation can predict how manufacturing variations can influence part yield.

ASIC often have poor absolute tolerance but maintain excellent relative tolerance. Matching the parameters of devices is crucial in analog-ASIC design. Device matching is especially important in determining the dc parameters of a circuit. Such dc parameters as offset voltage, input bias current, and input offset current limit how well an op amp can detect an input signal. These parameters limit an ASIC's accuracy when the offset voltage becomes indistinguishable from the input signal. For example, if the input signal is 500 μV and the offset voltage is 500 μV, determining whether an output results from the input signal or the offset voltage is impossible.

Zero offset voltages and currents are ideal, but random manufacturing variations can cause nonzero values to occur. A typical op-amp input stage consists of symmetrical, identical transistors. Offset errors result from imprecise matching of the transistors. The primary factors affecting mismatch are random variations in photolithographic resolution and in impurity diffusions.

For large samples, the offset voltage typically follows a Gaussian distribution with a mean of 0 and a standard deviation between 10 μV and 10 mV. To minimize the offset voltage, you must model the transistors' mismatch accurately for the simulator to predict dc circuit parameters. Accurate modeling demands that the semiconductor manufacturer generate device-characterization data specific to mismatch. Rather than absolute values of device parameters, the characterization data that you need are the differences between certain device parameters. The devices will usually have critical parameters matching to within 1% of one standard deviation.

The offset error of an emitter-coupled pair is caused by mismatches in the two transistors' base-width and emitter areas, base and collector doping levels, and collector load resistors. The offset-current mismatch is caused by β mismatch and collector-resistor mismatch. The model parameters that the semiconductor manufacturer should characterize for mismatch include the differences in the input stages' collector resistors, βs, and saturation currents. Again, statistical data obtained from device characterization can model this mismatch.

Because of the large amount of data that high-iteration statistical simulation produces, you'll need data-reduction tools to present the results in a concise form. Yield-analysis tools, histograms, and scatter plots are three such postprocessing tools.

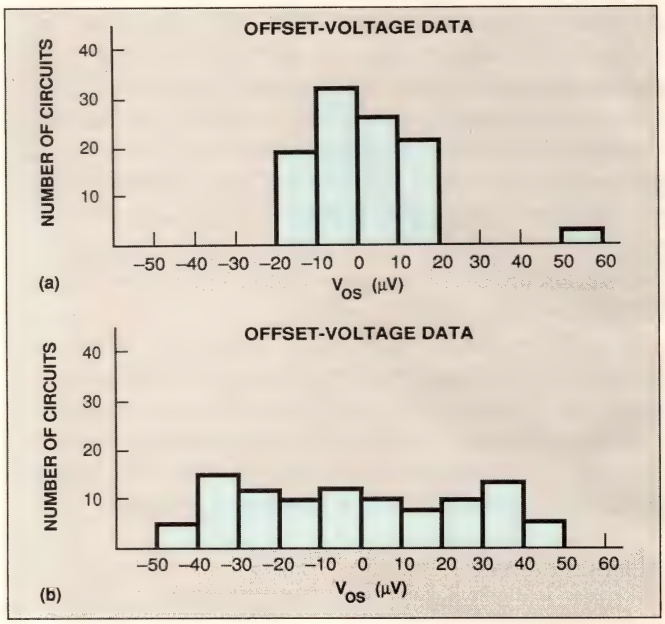


Fig 1—You can use histograms to help define a device's specifications. *Specifying V_{OS} between −30 and +30 μV would cause three devices to fail in* ***a****; substantially more devices would fail in* ***b****.*

Table 1—Yield-analysis data

Parameter	Limit	Individual yield	Mean	Standard deviation	Sample size
Offset voltage	$-20\ mV \le V_{OS} \le 20\ mV$	83%	3 mV	10 mV	150
Offset current	$-8\ \mu A \le I_{OS} \le 8\ \mu A$	100%	−1 μA	2 μA	150
Bias current	$-25\ \mu A \le I_{BIAS} \le 25\ \mu A$	100%	4 μA	6 μA	150
Open-loop gain	72 dB	88%	80 dB	4 dB	150
CMRR	72 dB	86%	79 dB	4 dB	150
Gain-bandwidth product	550 MHz	100%	600 MHz	10 MHz	150
Slew rate	550V/μsec	100%	600V/μsec	20V/μsec	150
Settling time	200 nsec	99%	180 nsec	10 nsec	150
Rise time	10 nsec	96%	7 nsec	2 nsec	150



8mm data storage. A lot has been written on it.

EXABYTE Corporation revolutionized the tape storage industry in 1987 by introducing the first 8mm cartridge tape subsystem. Since then, a lot has been written on it. Literally.

The capacity and speed of 8mm technology are well suited to meet today's data intensive storage requirements such as the backup of large computer systems or network data bases. In addition to traditional computer applications, 8mm storage is being used to collect forecasting data on high-altitude weather balloons, to record neurological and underwater research data, and to store medical images.

All this information is being stored on the same compact 8mm tape cartridge used in many of today's camcorders. Through the recording method called helical scan, it is now possible to store up to *2.5 gigabytes* on a single tape. That's the equivalent of 1,250,000 memos that would fill 68 four-drawer file cabinets, or a stack of business letters 42 stories high!

OEMs, VARs, and systems integrators incorporate 8mm products into their workstation, supermini, and mainframe computer environments so their customers can keep pace with today's information overload. And we are backing up some of the biggest names in the industry: Bull S.A., Data General, DEC, IBM, Motorola, NCR, Norsk Data, Northern Telecom, Prime Computer, Siemens, Sun Microsystems, Texas Instruments, 3Com and Wang Laboratories, just to mention a few.

To get the full story on 8mm data storage solutions, call us today at **(303) 447-7359** or write EXABYTE Corporation, 1685 38th Street, Boulder, CO 80301. And find out why there has been a lot written on 8mm.



The EXB-8200 8mm Cartridge Tape Subsystem
2.5-Gigabyte Capacity
246 Kbytes/Second Transfer Rate
Over 100,000 Drives Shipped

EXABYTE™
The Capacity to Succeed

EXATAPE is a trademark of EXABYTE Corporation.
©1990 EXABYTE Corporation

CIRCLE NO. 116

You need to collect lots of data points to accurately determine correlation coefficients.

Yield analysis summarizes yield to an individual specification or to a total set of specifications. To obtain individual and total yield projections, input a list of circuit output parameters and their specification limits. As **Table 1** shows, the yield-analysis tool produces the parameters, individual yield, mean value, standard deviation, and sample size (generally equal to the number of iterations in a Monte Carlo simulation). Correlation between output parameters explains why total yield is higher than the product of individual yields. Typically, yield-analysis tools can point to the parameters affecting yield. Histograms can provide a more detailed look at a particular parameter.

Histograms graph the number of circuits vs a circuit-output-parameter's value. Seeing the spread lets you judge what the output specification should be. **Fig 1a** shows a histogram of offset voltage, V_{OS}. Three circuits have a V_{OS} in the 50 to 60 μV range, and 97 circuits have a V_{OS} that falls between -20 and $+20$ μV. You can set the V_{OS} to $-20\ \mu V \leq V_{OS} \leq 20\ \mu V$ with only a 3% yield loss. **Fig 1b** shows a histogram of V_{OS} with a more uniform distribution. In this case, setting the specification at $-20\ \mu V \leq V_{OS} \leq 20\ \mu V$ will result in a 60% yield loss.

A scatter plot is a graph of two circuit parameters that determines their correlation coefficient. The coefficient can be used as a diagnostic tool to track the source of a design problem. Test engineers can use correlation coefficients to estimate a difficult-to-test parameter or to improve the test sequence. You can also use scatter plots as a diagnostic tool for ASICs. You can set up arrays to determine correlations between a problem output parameter and device parameters. In a sense, scatter plots are similar to sensitivity analysis. **Fig 2** is a representative scatter plot.

Parametric plots are a graphical aid you can use to assimilate the output data from parameter sweeps, sensitivity analysis, and other simulations in which you vary parameters. Parametric plotting typically graphs time, frequency, or temperature on one axis, and a circuit output parameter such as open-loop gain or CMRR on the other. A Bode plot of the gain and phase margin vs frequency is a common parametric plot. By varying a parameter and plotting each waveform on the same graph, you can create multiple parametric plots.

Usually, dc parameters are easier to test than ac parameters, so being able to draw conclusions about some tests on the basis of others may speed testing. Scatter plots might improve a test program if you plot a dc parameter vs an ac parameter. The software determines the correlation between the two parameters. If a high correlation exists between the two, you could use the dc test to draw conclusions about the ac test result.

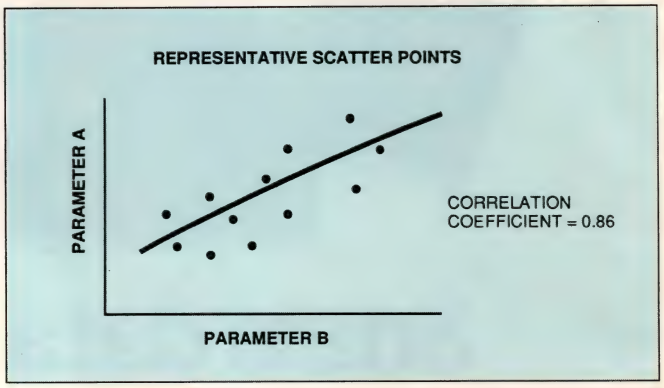
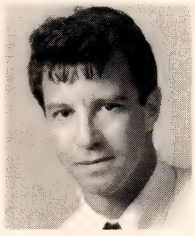


***Fig 2—Scatter plots provide data points** for approximating correlation coefficients.*

Suppose that the offset-voltage temperature coefficient is the parameter that most influences yield. Because this parameter is difficult to measure at wafer probe, measuring it after packaging the ASIC is a better alternative. To avoid packaging die that have a high probability of failing the offset-voltage temperature-coefficient test, search for a parameter that you can easily test at wafer probe and that has a high correlation with this spec. After finding that the input offset voltage correlates well with the offset-voltage temperature coefficient, you could determine the probe-test limits for the input offset voltage that would screen circuits that would fail the temperature-coefficient test. **EDN**

Author's biography



Lester Sanders is Harris Corp's (Melbourne, FL) analog-ASIC product manager. Although his current responsibilities center on product planning, he has worked on microprocessors, LANs, and encryption circuits. Lester earned his BS at Tulane University and his MSEE at Florida Atlantic University. He has completed a graduate program in business at the University of Florida.

Article Interest Quotient (Circle One)
High 491 Medium 492 Low 493

Presenting a battery that's not for everyone.



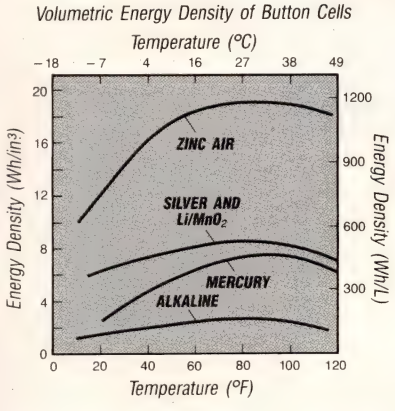
The DURACELL® Zinc Air DA1204 Cell: Only for the high energy designer.

*Our new zinc air battery isn't for everyone. But if you need a small battery with high energy, it may be for you. Since the DA1204 uses the air we breathe as the cathode, it packs more energy for its size than any battery on the market. In fact, it gives you C cell size capacity (6.6 ampere hours) in less than one-third the size.**

Sealed and waiting to be used, the DA1204 has a long shelf life — maintaining 98% of capacity after one year of storage. But because it is an air-powered battery, the DA1204 has a three month life once unsealed. It performs at a constant output voltage and is perfectly suited for medium drain, continuous-use applications with average current requirements up to 150mA. And it's available in single or multi-cell configurations.

The DURACELL Zinc Air DA1204 cell isn't for everyone, but it may be the high-energy solution you're looking for. Find out more. Call or write for complete technical information on Duracell's full line of Zinc Air batteries.

**Batteries shown 150% of actual size.*



DURACELL INC.

New Products and Technology Division
OEM Sales and Marketing
Berkshire Industrial Park
Bethel, CT 06801
Toll-free: 1-800-422-9001 ext. 425
Fax: 203-791-3273

©1989, Duracell, Inc.



Communication solutions from Rockwell.

The assignment was demanding. The integral modem for the company's new Laptop would have to be compact and inexpensive. With the complete '88 AT command set, plus the lowest possible power consumption.

"The features they packed into the world's first single-device V.22bis modem blew us away."

Fortunately, the engineers already know who to call: Rockwell International. They're aware that no matter what the application, Rockwell's new V.22bis family provides capabilities nobody else can supply.

They've read how Rockwell stunned the industry with its RC224AT—the world's first fully integrated single-device modem solution. And how this one compact component offers CCITT V.22bis and V.22, as well as Bell 212A and 103 compliance, plus value-added features such as power-saving Automatic Sleep Mode. Not to mention the assurance of a five-year warranty.

Their call to Rockwell also reveals how the V.22bis family can help with future projects. They learn about the capabilities of Rockwell's RC2324DP chip set.

They hear how it provides HDLC/SDLC framing for implementing MNP 5™, X.25, LAPM and V.42 protocols, while offering unprecedented programming flexibility for custom and country-specific applications.

"And then we met the rest of the family."

A Rockwell technical advisor explains that it's the only chip set with Quad capability that meets CCITT V.22bis, V.22A/B, V.21 and V.23 requirements, as well as Bell 212A and 103 standards. He adds that the RC2324SME offers capabilities optimized for Europe, including MNP 5™ and V.25bis.

In no time, the Laptop project is ready for production. To management, the results—as well as the engineers responsible—couldn't look better.

Call the leader in modem technology. Rockwell *is* solutions.



Rockwell International

...where science gets down to business

Aerospace/Electronics/Automotive
General Industries/A-B Industrial Automation

Semiconductor Products Division
Rockwell International
P.O. Box C, M.S. 501-300
Newport Beach, CA 92658-8902
(800) 854-8099
In California, (800) 422-4230

CIRCLE NO. 123

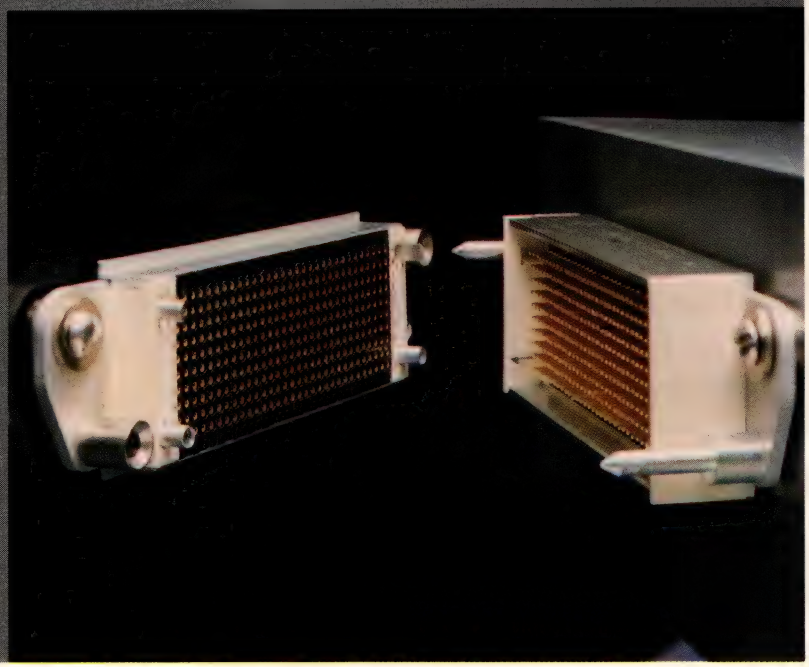
End the connector compromise...

1. 70 TO 350 LOW INSERTION FORCE CONTACTS

2. CONTACT WIPE ELIMINATES INTERMITTANCE

3. MIL-C-28748A RELIABILITY

...in electronic equipment

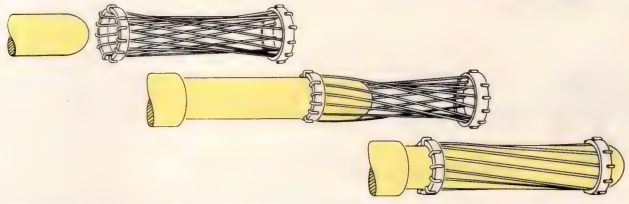


Only Hypertronics ends the compromise in multi-pin connectors for disc drive, burn-in and other rack & panel applications...by combining Low Insertion Force (LIF) connections with high cycle life reliability and a blind mating tolerance up to .049″ radial misalignment.

Our N Series design provides 70 to 350 LIF contacts with solder cup, crimp, flow solder or wire wrap terminations. The contact is rated at 3 amps at less than 5 milliohms over a mechanical cycle life in excess of 100,000 operations.

The inherent wiping action of each Hypertronics® contact maintains electrical continuity under corrosive conditions and extremes of shock and vibrations...ending the intermittance problems of Zero Insertion Force (ZIF) contacts. The use of the Hypertronics® LIF contact, with average insertion force of one ounce, eliminates the need for jack screws, cam levers and other mechanical assists... to reduce cost, weight and size, while increasing reliability.

HYPERTAC®: Inserting pin into hyperboloid sleeve.



IN A HURRY? FAX-REFAX

For information and fast response. FAX 508-568-0680 for the "N" Series FAX/PAK...and we'll FAX you back.

HYPERTRONICS CORPORATION

"New Horizons in Connectors"

16 Brent Drive, Hudson, MA 01749 (508) 568-0451 Telex 951152 FAX (508) 568-0680

HDL design methods simplify specs and boost productivity

Combining HDLs (hardware-description languages) with logic-synthesis techniques can boost your design productivity by allowing you to explore alternative design approaches.

Karen Vahtra, *Synopsys Inc*

With today's complex designs, the traditional "back-of-the-envelope sketch" approach to architectural design is no longer effective. HDLs play an important role in system specification and high-level design. Over the past few years, ASIC designers have begun to use HDLs to test block specifications in their ASICs in context with other blocks and entire systems. You can now write an HDL model and rapidly synthesize a matching set of gates, consequently spending more time exploring design alternatives to create better designs.

HDLs first played an important role in IC design in the early eighties when design-automation vendors introduced mixed-mode simulators. The new mixed-level environment allowed designers to simulate an entire design, from architectural specification to gate-level design, using any combination of compact HDL models and detailed schematics. When the specification was complete, designers manually decomposed the HDL models into logic gates. In the late eighties, design-automation vendors introduced a new technology: logic synthesis.

Logic synthesis takes an HDL-based design and automatically translates it into a gate-level description and then optimizes it for speed and area. This new technology guarantees a functional equivalence between the HDL specification and the gate-level implementation. You direct the synthesis process by specifying information to the logic-synthesis tool. The information includes such items as the required target technology, clock speed, maximum gate count, and operating conditions.

Motivation behind HDL

An HDL design methodology meets several needs associated with today's large designs and team-based engineering approach. Large designs in particular require a means to rigorously specify the design in advance so that all team members can work toward a common goal. The team needs a method of testing individual designs in the context of the entire system. It's important to catch interface problems, which almost always plague designs, early in the design cycle. Also, the team needs a method of testing alternatives, or tradeoffs, early in the design cycle to determine the best engineering course.

HDL models provide the mechanism for architectural specification, simulation verifies the functional operation of the design, and logic synthesis frees you

An HDL design methodology meets several needs associated with today's large designs and team-based engineering approach.

from the burden of translating a design from an HDL description into a gate-level design in the target technology. All these factors add up to both higher-quality designs and drastically improved productivity.

Fig 1 shows a flow chart of HDL design. After specifying the design in an HDL model, you simulate and modify the model as needed until it is functionally correct. The synthesis step takes the HDL model and automatically decomposes the HDL description into a gate-level description. If the gate-level description produced from synthesis does not meet the detailed system specifications, you need only modify the HDL model and automatically regenerate the gate-level description. Also, if the detailed specification (including new features and functionality) evolves over time, you simply effect the changes in the HDL model. Once the final gate-level description is simulated, the design is ready for silicon. The HDL design methodology satisfies three basic engineering needs: a readable and design specification that can be simulated; automatic gate-level synthesis; and tradeoff analysis.

Design specification becomes a larger and more important task as design complexity increases and design staffs grow. Without a detailed design specification, design boundaries and interface details become prone to misinterpretation, and the development process quickly degrades. HDL specifications, which are inherently more readable and precise than their jotted-on-paper predecessors, provide an unambiguous and verifiable design specification. Simulations of the HDL models early in the design cycle allow you to discover any inherent flaws in the design approach.

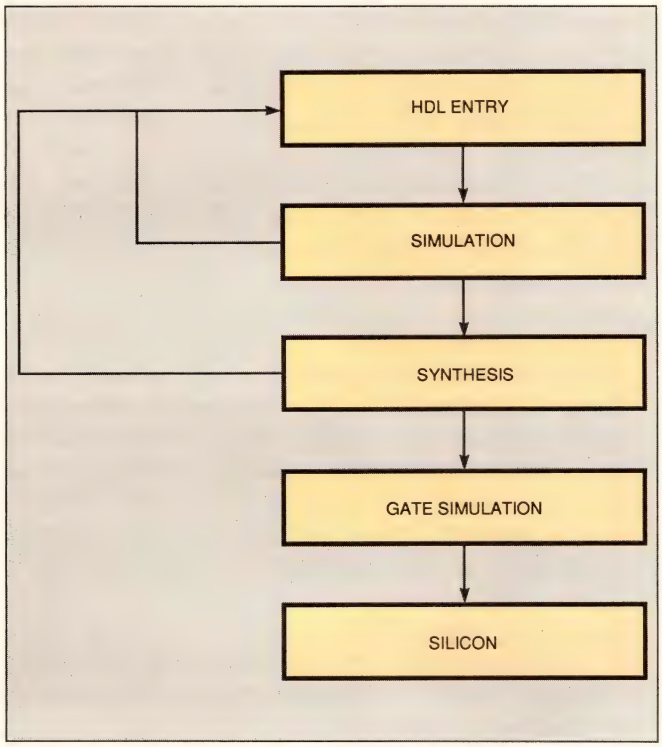


Fig 1—HDL, combined with simulation and synthesis, *provides the mechanism for architectural specification, design verification, and translation from design to silicon.*

Using a hierarchical design strategy, you can create well-defined architectural interfaces by simulating each HDL model alone and then simulating the entire system of HDL models. These early simulations eliminate the otherwise complicated task of integrating independently developed design blocks at the end of the design process. Complications can arise from the fact that these individually developed blocks may or may not have compatible I/O lines and timing assumptions. Once you precisely define the high-level architecture, the HDL models literally become the final specification that you use for documentation.

Logic synthesis greatly reduces the time required to decompose a specification into a gate-level description. Using a tool such as Synopsys' HDL Compiler and Design Compiler, you provide an HDL description and performance specifications, and the synthesis tool will build an optimized gate-level design according to the timing and area requirements. You save time by avoiding the manual process of decomposing the specification into gates, and you eliminate the time-consuming process of tweaking the design to meet performance objectives. If an initial HDL model does not meet the specifications, you can make changes to the model and synthesize a new description, or you can reoptimize the design with alternate design constraints. The HDL always provides up-to-date documentation of the circuit's function.

You can easily determine accurate design tradeoffs by comparing speed and area results between the synthesized gate-level representations. For example, you can quickly determine the number of registers, the instruction set, or the memory configuration needed. If gate-level descriptions do not meet their needs, you can explore alternatives such as different architectures, speed-area tradeoffs, or even different ASIC technologies. With the time and ability to explore different design tradeoffs, you can optimize the final design for speed, area, and cost.

To better understand HDL design methodology, consider a sample design problem and two solutions to

that problem using VHDL (**Ref 1**). VHDL, the VHSIC hardware description language, is the IEEE HDL standard 1076-1987. In MIL-STD-454L, the DoD dictates the use of VHDL to document all ASIC designs. The CAE industry is responding with VHDL simulators and logic-synthesis tools. For this example, consider the design of an interrupt controller. You could adopt the approach used in designing a previous controller, or you could discover other possible architectures by brainstorming, discussing ideas with colleagues, or looking up techniques in textbooks.

A variety of system architectures, among them polled or vectored schemes, are available to implement an interrupt controller. In a polled system, software polls each device and checks for interrupt requests. In a vectored system, all interrupts are based in hardware. For a vectored system, the only established requirements are to service eight devices on a priority basis using hardware only. Two architectures come to mind. The first is an asynchronous architecture. An asynchronous system processes the incoming interrupt requests and places the address of the highest priority device requesting an interrupt on a bus, using 3-state devices.

The second architecture is a synchronous approach, which requires you to service an interrupt at every clock edge. This scheme requires the incoming interrupt requests to be synchronous with the clock. Although this requirement is atypical for interrupt controllers, the architecture represents a valid approach for exploring a simple example of design tradeoffs. The two possible approaches are a 3-state architecture or a flip-flop architecture. Using a logic-synthesis tool and VHDL descriptions for these architectures, we can explore the tradeoffs for a design that uses an ASIC operating under a worst-case commercial environment with a prelayout statistical-wire-loading module size of 1×1 mm.

System requirements

For this example of a disk interrupt controller, eight different devices, 0 through 7, can request system interrupts. Conceptually, the disk controller is device 7; the disks are subdevices to the controller. The interrupt controller processes these interrupt requests, with the highest priority given in sequence to device 7, down to the lowest-priority device, 0. The interrupt controller will always serve an interrupt from device 7 first, even if other devices request interrupts at the same time. When an interrupt controller receives a request, it places a 1 on the interrupt output line and puts the address of the device on the interrupt address line. In **Fig 2**, device 7 is the disk-controller card, which supports as many as four different disks. Because of the critical nature of a disk interrupt, the interrupt 7 signal can arrive 5 nsec later than any other interrupt request and still receive first priority.

When an interrupt occurs from the disk-controller card, the interrupt controller sends the correct interrupt address to the CPU. This interrupt address contains the disk-controller address on the higher bits of the address line and the actual disk-drive subaddress

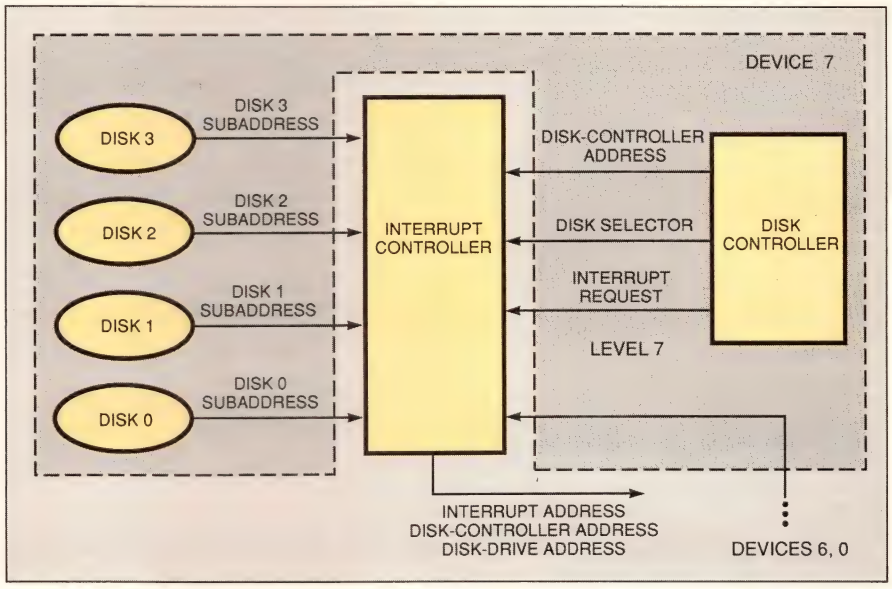


Fig 2—This disk interrupt controller intercepts interrupt requests *and assigns priority to device 7 of the eight devices that can request system interrupts.*

A variety of system architectures, among them polled or vectored schemes, are available to implement an interrupt controller.

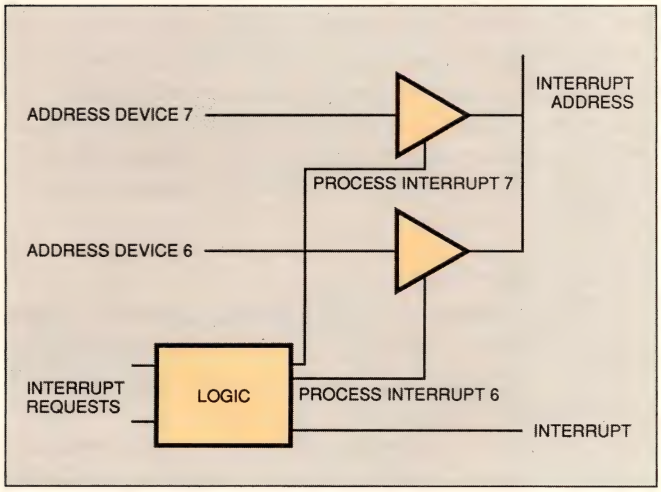


Fig 3—In this 3-state architectural structure, *if an interrupt 7 arrives, the 3-state gates corresponding to address 7 are enabled, placing address 7 on the interrupt bus.*

on the lower bits. The disk controller then informs the interrupt controller of the disk-controller address, requests the actual interrupt, and tells the interrupt controller the number of the active disk drive with the disk-selector bus. The interrupt controller then places the disk-controller address on the high bits of the interrupt address line, decodes the disk selector, reads the correct disk subaddress that the individual disk supplies, and places this address on the lower bits of the interrupt address line.

Fig 3 illustrates the 3-state architecture. If an interrupt 7 occurs, the 3-state gates corresponding to address 7 are enabled, placing address 7 on the interrupt address bus. All other 3-state devices are disabled. Similarly, if an interrupt occurs for device 6, address 6 is placed on the address line, and all other 3-state devices are disabled.

The 3-state VHDL approach described here concentrates on the entity and architecture sections. The entity declaration lists the input and output ports for the interrupt controller. The architecture section contains the functional description of this interrupt controller. **Fig 4** is the entity declaration for this VHDL architectural description.

The declaration begins with the word "entity", followed by the name of the entity, INTERRUPT_CONTROLLER. Between the words "is port(" and the closing brace ")", which follows MVL_VECTOR(0 to 4), is the list of input and

```
entity INTERRUPT_CONTROLLER  is port( -- part name
INTERRUPT_CONTROLLER


  DEV7_INTR_REQ, DEV6_INTR_REQ, DEV5_INTR_REQ,
  DEV4_INTR_REQ, DEV3_INTR_REQ, DEV2_INTR_REQ,
  DEV1_INTR_REQ, DEV0_INTR_REQ       : in BIT;
    -- devices send in 1-bit interrupt request line
  DISK_DRIVE_SELECTOR, -- determines the lower address for device 7
  DISK_DRIVE3_ADDR, DISK_DRIVE2_ADDR,
  DISK_DRIVE1_ADDR, DISK_DRIVE0_ADDR : in BIT_VECTOR(0 to 1);
    -- devices 7 uses these addresses for the lower two disks
  DEV7_ADDR, DEV6_ADDR, DEV5_ADDR,
  DEV4_ADDR, DEV3_ADDR, DEV2_ADDR,
  DEV1_ADDR, DEV0_ADDR        : in BIT_VECTOR(0 to 2);
    -- each device has 3-bit address
  INTERRUPT                   : out BIT; -- interrupt?
  INTERRUPT_ADDR              : out MVL_VECTOR(0 to 4));
    -- interrupt address


end INTERRUPT_CONTROLLER;
```

Fig 4—The entity declaration for the 3-state architecture *lists the input and output ports for the interrupt controller. Because the BIT output designation can't handle 3-state logic, INTERRUPT_ADDR bus is declared as an MVL_VECTOR.*

output ports. For example, DEV7_INTR_REQ, DEV6_INTR_REQ are all "in BITs," where an "in BIT" is an input of type BIT. The BIT type is a standard VHDL type, and can either be a 1 or a 0. Each of the eight devices has an interrupt request line, DEV7_INTR_REQ down to DEV0_INTR_REQ. The DISK_DRIVE_SELECTOR and the three disk-drive address buses such as DISK_DRIVE3_ADDR are the type in BIT_VECTOR(0 to 1). These five lines are two arrays of BITs. The "—" symbol denotes the beginning of a comment.

The device addresses, such as DEV7_ADDR, are 3-bit-wide vectors. The two outputs of the interrupt controller are the INTERRUPT of type BIT, and the INTERRUPT_ADDR. Because INTERRUPT_ADDR is on a 3-state bus, the two logic values available with type BIT are insufficient. For this reason, the INTERRUPT_ADDR bus is declared as a MVL_VECTOR(0 to 4). The MVL (multiple-valued logic) type is an enumerated type with additional support of a high-impedance state in addition to the 1 and 0 values. The first part of the architectural body is shown in **Fig 5.**

The architectural declaration begins with the name of the architecture, THREE_STATE_ARCH, of the design called INTERRUPT_CONTROLLER. This design contains a few additional declarations within this section—for example, two internal signals, ENABLE and NEXT_ADDR. The enable lines will activate the correct 3-state devices, allowing the correct address to pass through. For example, ENABLE(7) will enable the 3-state devices corresponding to device 7. The NEXT_ADDR signal computes the correct full address for a disk-controller interrupt. This signal is 5 bits wide—3 bits for the disk-controller address, and 2 bits for the disk-device address.

Two component declarations list the input and output ports for the lower-level structural components used later in this architecture. A component declaration allows you to insert separate entities as hierarchical elements. The contents of these components are declared in a separate entity/architecture pair. By inserting hierarchical components, the final set of VHDL descriptions becomes easier to understand. The first hierarchical component in this example is the THREE_STATE

```
 Architecture THREE_STATE_ARCH of INTERRUPT_CONTROLLER  is
   -- three-state architecture for the entity

signal ENABLE                       : BIT_VECTOR(0 to 7);
   -- enables the three-state address
signal NEXT_ADDR                    : BIT_VECTOR(0 to 4);
   -- holds the next interrupt address

component THREE_STATE -- hierarchical module of one three-state
device
   port (D,E : in BIT; Q : out MVL); -- two inputs D and E. output Q
end component;

component TRI_BY_THREE  -- declares hierarchical module of three
three-state devices
   port (D : in BIT_VECTOR(0 to 2); E: in BIT; Q : out MVL_VECTOR(0 to
2));
end component; -- 3-bit-wide D input
               -- common enable line E
               -- 3-bit-wide output Q

begin -- begin architecture
```

Fig 5—This VHDL architecture description for the 3-state interrupt controller *contains the complete functional description of the controller. Two component declarations list the input and output port lists for the lower-level structural components used in the architecture.*

After simulating the VHDL description, use the HDL compiler and design compiler to synthesize the architecture into gates, and then to optimize it.

register with a data line (D), an enable line (E), and an output (Q) of type MVL. The TRI_BY_THREE register declaration supports three 3-state devices with a common enable line. Each register has a 3-bit data input, a 1-bit enable line, and a 3-bit output vector. (For brevity, this discussion omits the structural declarations.) Two declarations are for the 1-bit 3-state devices supporting the two upper address bits of device 7, and eight instantiations (manually specifying a device within a description, rather than letting the software do it) tie in the device address to the lower bits of the INTERRUPT_ADDRESS with the common enable lines.

The second part of the architectural body is the DETECT_INTERRUPT process shown in **Fig 6**. This section defines a process that determines whether or not an interrupt occurred and whether or not the corresponding correct set of enable lines are set. A process statement is an ordered collection of sequential statements. The behavior of a process is defined by its sequence of statements, which are repeatedly executed. VHDL uses a unique <= symbol to designate a signal assignment; variable assignments use the := designation. The statement, ENABLE <= BIT_VECTOR'(others => '0'), states that the resulting value of the operation is a BIT_VECTOR, with the value determined after the first tick mark or in the statement, (others => '0'). This statement assigns all other values in the width of the bus to zero.

The second statement assigns the INTERRUPT line high (INTERRUPT <= '1'). Because the interrupt has only a 1-bit value, the assignment statement places

```
DETECT_INTERRUPT : process -- determine the highest priority interrupt

begin
ENABLE <=  BIT_VECTOR'(others => '0'); -- all bits of ENABLE assigned
0
INTERRUPT <= '1'; -- INTERRUPT assigned 1

     -- determine the highest-priority device and set the
corresponding bit

if DEV7_INTR_REQ = '1' then ENABLE(7) <= '1';   -- interrupt on device
7?
   elsif DEV6_INTR_REQ = '1' then ENABLE(6) <= '1';    -- interrupt on
device 6?
   elsif DEV5_INTR_REQ = '1' then ENABLE(5) <= '1';    -- interrupt on
device 5?
   elsif DEV4_INTR_REQ = '1' then ENABLE(4) <= '1';
   elsif DEV3_INTR_REQ = '1' then ENABLE(3) <= '1';
   elsif DEV2_INTR_REQ = '1' then ENABLE(2) <= '1';
   elsif DEV1_INTR_REQ = '1' then ENABLE(1) <= '1';
   elsif DEV0_INTR_REQ = '1' then ENABLE(0) <= '1';
   else INTERRUPT <= '0';                        -- no interrupt
requests
 end if;

end process DETECT_INTERRUPT;
```

***Fig 6—The second part of the interrupt controller's architectural body** is in this DETECT_INTERRUPT process. This process determines whether or not an interrupt has occurred, and if the corresponding correct set of enable lines are set.*

a 1 on the INTERRUPT line. If an INTERRUPT does not occur, the value of the INTERRUPT line will be set low later in the description. The next statements in the VHDL code check each device request line in order of priority. If device 7 requests an interrupt, then ENABLE(7) is assigned a high value. This functionality is accomplished with the statement, if DEV7_INTR_REQ = '1' then ENABLE(7) <= '1'. If device 7 does not request an interrupt, the elsif clauses can check for a request from device 6 down to device 0. If no devices are requesting an interrupt, the INTERRUPT line is reset low. The third part of the architectural body is the CALCULATE_ADDRESS process shown in **Fig 7**.

A second process calculates the correct address, NEXT_ADDR, for device 7. This process declares a local variable, DISK_ADDR, to store the address of the currently active disk. NEXT_ADDR is assigned a value of 0 initially. If an interrupt occurs on device 7, the case statement checks the value of the DISK_DRIVE_SELECTOR. The statement works with a series of corresponding "when" statements. If the value of the operator used in the case statement, in this case the DISK_DRIVE_SELECTOR, is equal to any of the values after the word "when", such as "11", the corresponding assignment statement occurs. For a 01 value of the DISK_DRIVE_SELECTOR, the DISK_ADDR is assigned the current value of the DISK_DRIVE1_ADDR. Again, if the DISK_DRIVE_SELECTOR is 3, the address of device 3 is placed on DISK_ADDR. The two assignment statements correctly arrange the address. The first assignment statement moves the disk-controller address to the higher-order bits, and the second statement places the disk subaddress on the lower-order bits.

After simulating the VHDL description, the next step is to use the HDL compiler and design compiler

```
CALCULATE_ADDRESS : process -- calculate the correct address
variable DISK_ADDR : BIT_VECTOR(0 to 1); -- holds the lower two
address bits
begin
NEXT_ADDR <= BIT_VECTOR'(others => '0'); -- initialize to all zeros

if DEV7_INTR_REQ = '1' then                          -- interrupt on
device 7?
   case DISK_DRIVE_SELECTOR is   -- If yes, calculate the disk
subaddress
     when "11" => DISK_ADDR := DISK_DRIVE3_ADDR;
          -- if 3, use DISK_DRIVE3_ADDR
     when "10" => DISK_ADDR := DISK_DRIVE2_ADDR;
          -- if 2, use DISK_DRIVE2_ADDR
     when "01" => DISK_ADDR := DISK_DRIVE1_ADDR;
     when "00" => DISK_ADDR := DISK_DRIVE0_ADDR;
   end case;
 NEXT_ADDR(2 to 4) <= DEV7_ADDR(0 to 2);          -- shift up address
 NEXT_ADDR(0 to 1) <= DISK_ADDR(0 to 1);          -- include drive
address
 end if;

 end process CALCULATE_ADDRESS;
 end THREE_STATE_ARCH;
```

***Fig 7—Part three of the architectural body of the controller** is embedded in the CALCULATE_ADDRESS process. If an interrupt occurs on device 7, the case statement checks the value of the DISK_DRIVE_SELECTOR. The case statement works with corresponding when statements in placing the addresses of the devices on DISK_ADDR.*

The combination of HDL design with logic synthesis provides you with an extremely powerful tool.

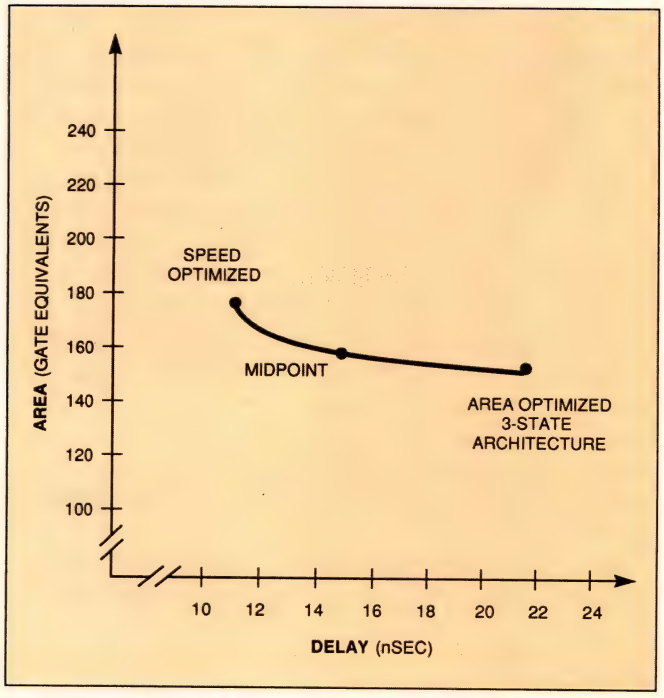


***Fig 8—Design tradeoffs for the 3-state architecture** are evident in this graph. Optimal speed (least delay) entails the greatest number of gates, and the most area-efficient design suffers the highest delay. The midpoint design represents a compromise.*

to synthesize the architecture into gates, and then to optimize it. The example given entails three synthesis runs. In the first run, the design compiler receives instructions to make the smallest possible design. In the second run, the spec configures the optimization process to produce the fastest possible design. The third run creates a midpoint design with an even tradeoff between chip area and speed.

All three optimizations assume a 5-nsec arrival time on DEV7_INTR_REQ. This constraint accounts for the specification that allows device 7's interrupt request to arrive 5 nsec later than any other signal. **Fig 8** illustrates the design-space tradeoffs for the 3-state architecture.

Table 1 lists the actual numbers for each of the three synthesis runs. The design-space curve is relatively horizontal for the 3-state architecture. The fastest design executes in a little over 10 nsec, or double the speed of the area-efficient design, yet it requires only 34% more area. **Fig 9** shows an automatically generated schematic of the fastest implementation.

Fig 10 illustrates the concept behind the flip-flop architecture. This implementation is synchronous and

Table 1—3-state synthesis results

Design	Area (gate equivalents)	Delay (nsec)
Area optimized	151	21.8
Delay optimized	202	10.6
Midpoint tradeoff	153	14.9

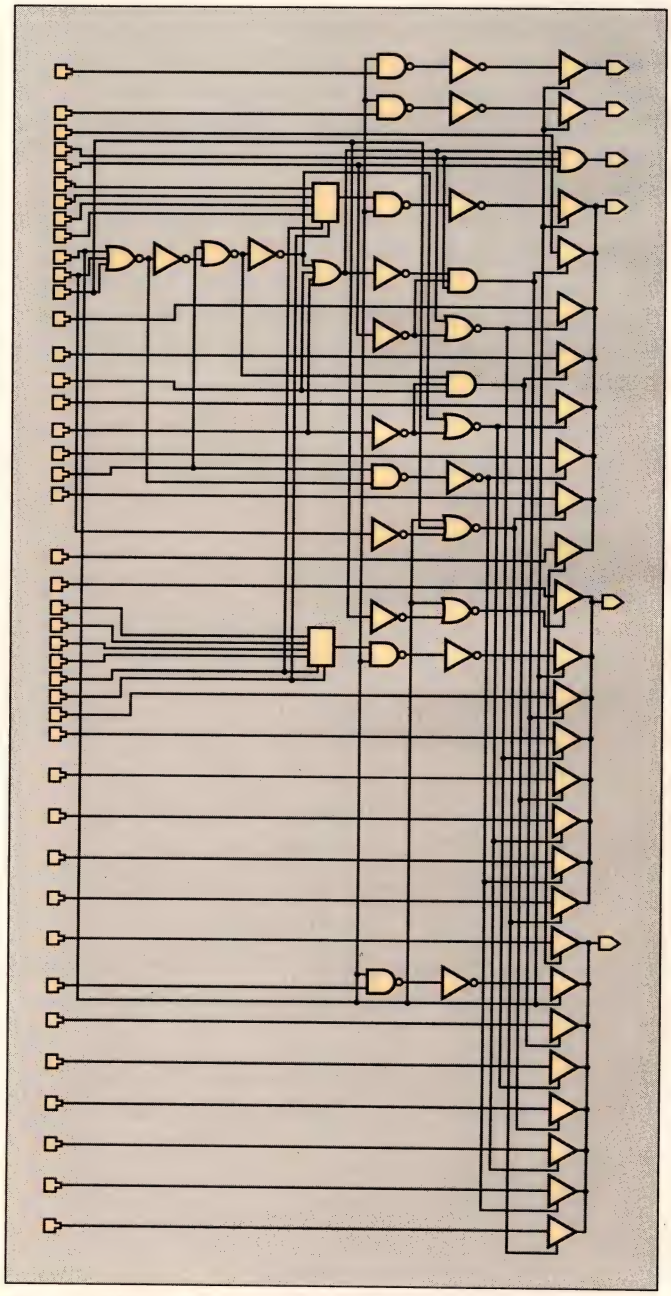


***Fig 9—Optimized for the least delay in the 3-state architecture,** this circuit uses 202 gate equivalents and has a 10.6-nsec delay.*

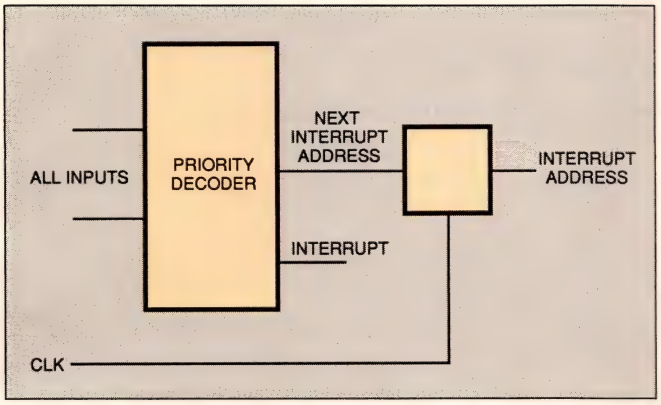


Fig 10—A synchronous interrupt controller uses a flip-flop architecture. *The interrupt requests must be synchronous with the clock signal. The priority detector determines the highest priority device and the next interrupt address.*

requires that the interrupt requests also be synchronous with the new clock signal. The priority detector determines the highest priority device and the next interrupt address. The flip-flops receive their clocking from the clock signal, which stabilizes the address.

Fig 11 is the VHDL entity and architecture. This description is similar to the one for the 3-state architecture. The first process, CALCULATE_ADDRESS, calculates the NEXT_ADDR and detects an interrupt. An additional variable, NEW_ADDR, computes the NEXT_ADDR within the process. A case statement and two assignment statements support the subaddress requirements of address 7. Nested if-then-else statements determine the correct priority interrupt in a way that is similar to the process for the 3-state architecture. The second process, STORE_ADDRESS, assigns the actual output, INTERRUPT_ADDR, at the rising edge of the clock.

The entity declaration section differs from the one for the 3-state architecture in two ways. First, the flip-flop architecture needs a CLK input signal. The 3-state architecture requires the MVL_VECTOR type for the INTERRUPT_ADDR to support the high-impedance value. The flip-flop architecture raises no worries about contention; it uses a simple BIT_VECTOR type for the INTERRUPT_ADDR. In the flip-flop architecture, the 3-state DETECT_INTERRUPT process merges into the CALCULATE_ADDRESS process because the assignment of NEW_ADDR depends upon the priorities of both the interrupt and the subdisk drive.

The actual statements supporting the disk-drive selection are identical in the two architectures. The two if-then-else blocks appear similar, but in fact differ significantly in behavior. In the 3-state architecture, this section alters the enable line of the correct set of 3-state devices. In the flip-flop architecture, it assigns to the NEW_ADDR variable the value of the current interrupt address, which is serviced at the next clock edge. The 3-state architecture instantiates the components directly within the description.

The second process statement, STORE_ADDRESS, determines the flip-flop architecture. This process statement waits for a rising clock edge and places the NEXT_ADDR on the INTERRUPT_ADDR output. The wait statement—wait until (CLK'event and CLK='1')—accomplishes this synchronization.

A process operates continuously through time. The wait statement will hold up the execution until the condition is valid. The condition specified here is that an event occurred on the clock signal and the CLK is now a logic 1. An event is defined as a change in values—it occurs when a signal changes from 1 to 0 or from 0 to 1. In this example, the wait statement executes only on the rising edge of the clock (a change occurs on the clock with a resulting value of 1). After the wait statement is the following statement: INTERRUPT_ADDR <= NEXT_ADDR. Because the INTERRUPT_ADDR is updated only after every rising clock, these statements directly infer the five flip-flops to store each of the 5 bits of the output address.

The HDL compiler and design compiler assume the task of synthesizing the flip-flop architecture into gates. As with the 3-state architecture, the HDL tools perform three different synthesis runs for the flip-flop architecture. **Table 2** lists the results. In this case, to speed up the design by 25% (from 16.8 to 12.3 nsec), the design needs double the area (from 116 to 232 gate equivalents). **Fig 12** shows a schematic of the area-efficient flip-flop architecture.

Fig 13 illustrates the design-space tradeoffs for both the flip-flop and the 3-state architectures. On the design-space curve for the flip-flop architecture, the speed-optimized version appears in the upper left cor-

Text continued on pg 258

Table 2—Flip-flop synthesis results

Design	Area (gate equivalents)	Delay (nsec)
Area optimized	116	16.8
Delay optimized	232	12.3
Midpoint tradeoff	139	14.6

```
entity INTERRUPT_CONTROLLER is port( -- new entity declaration

CLK                                                    : in BIT;
    -- additional clk input signal
DEV7_INTR_REQ, DEV6_INTR_REQ, DEV5_INTR_REQ,
DEV4_INTR_REQ, DEV3_INTR_REQ, DEV2_INTR_REQ,
DEV1_INTR_REQ, DEV0_INTR_REQ                           : in BIT;
    -- devices send in 1-bit interrupt requests lines
DISK_DRIVE_SELECTOR,     -- determines the lower address for device 7
DISK_DRIVE3_ADDR, DISK_DRIVE2_ADDR,
DISK_DRIVE1_ADDR, DISK_DRIVE0_ADDR                     : in BIT_VECTOR(0
to 1);
    -- device 7 uses these addresses for the lower two bits
DEV7_ADDR, DEV6_ADDR, DEV5_ADDR, DEV4_ADDR,
DEV3_ADDR, DEV2_ADDR, DEV1_ADDR,
DEV0_ADDR                                  : in BIT_VECTOR(0 to 2);
    -- each device has 3-bit address
INTERRUPT                                  : out BIT;  -- interrupt?
INTERRUPT_ADDR                             : out BIT_VECTOR(0 to 4));
    -- interrupt address
end INTERRUPT_CONTROLLER ; -- end entity INTERRUPT_CONTROLLER

Architecture FLIP_FLOP of INTERRUPT_CONTROLLER is -- flip-flop
architecture
      signal NEXT_ADDR              : BIT_VECTOR(0 to 4);
              -- holds next interrupt address
begin

CALCULATE_ADDRESS : process -- determine priority and address
variable STOP                 : BIT; -- holds interrupt request
variable NEW_ADDR             : BIT_VECTOR(0 to 4) ; -- full
address
variable DISK_ADDR            : BIT_VECTOR(0 to 1) ; -- lower 2
address bits

begin

STOP := '1';                                -- assume an interrupt
NEW_ADDR <=  BIT_VECTOR'(others => '0');    -- clear device 7 addr
```

Fig 11—The entity and architecture process for the flip-flop-based controller *is similar to the one for the 3-state architecture. The flip-flop structure poses no contention problems, and does not need the MVL_VECTOR required by the 3-state architecture to support the high-impedance state.*

```
if DEV7_INTR_REQ = '1' then                    -- interrupt on device 7?
   case DISK_DRIVE_SELECTOR is                 -- select subaddress
     when "11" => DISK_ADDR := DISK_DRIVE3_ADDR;
               -- if 3, use DISK_DRIVE3_ADDR
     when "10" => DISK_ADDR := DISK_DRIVE2_ADDR;
               -- if 2, use DISK_DRIVE2_ADDR
     when "01" => DISK_ADDR := DISK_DRIVE1_ADDR;
     when "00" => DISK_ADDR := DISK_DRIVE0_ADDR;
   end case;

NEW_ADDR(2 to 4) := DEV7_ADDR(0 to 2);     -- shift up controller
address
NEW_ADDR(0 to 1) := DISK_ADDR(0 to 1);     -- include disk address

   elsif DEV6_INTR_REQ = '1' then NEW_ADDR := DEV6_ADDR;
         -- if 6 is highest priority use DEV6_ADDR
   elsif DEV5_INTR_REQ = '1' then NEW_ADDR := DEV5_ADDR;
         -- if 5 is highest priority use DEV5_ADDR
   elsif DEV4_INTR_REQ = '1' then NEW_ADDR := DEV4_ADDR;
   elsif DEV3_INTR_REQ = '1' then NEW_ADDR := DEV3_ADDR;
   elsif DEV2_INTR_REQ = '1' then NEW_ADDR := DEV2_ADDR;
   elsif DEV1_INTR_REQ = '1' then NEW_ADDR := DEV1_ADDR;
   elsif DEV0_INTR_REQ = '1' then NEW_ADDR := DEV0_ADDR;
   else STOP:='0';                                    -- no interrupts?

   end if;

INTERRUPT <= STOP;                                    -- assign stop to
interrupt
NEXT_ADDR <= NEW_ADDR;                                -- assign to output
end process CALCULATE_ADDRESS;

STORE_ADDRESS : process  -- assign address at clock edge
  wait until ( CLK'event and CLK='1');       -- wait for rising edge of
ck
   INTERRUPT_ADDR <= NEXT_ADDR;              -- assign to output
end process STORE_ADDRESS;

end FLIP_FLOP; -- end architecture
```

ner; the area-optimized version appears in the lower right corner.

The two curves illustrate the architectural tradeoffs. You would probably use the flip-flop architecture in a design that has strict area requirements. If speed is the primary issue, you'd most likely use the 3-state architecture. In 20 minutes, you can quickly perform six synthesis runs, and then evaluate the tradeoffs for each architecture. The speed of the HDL technique allows you to rapidly explore architectures that you might otherwise overlook.

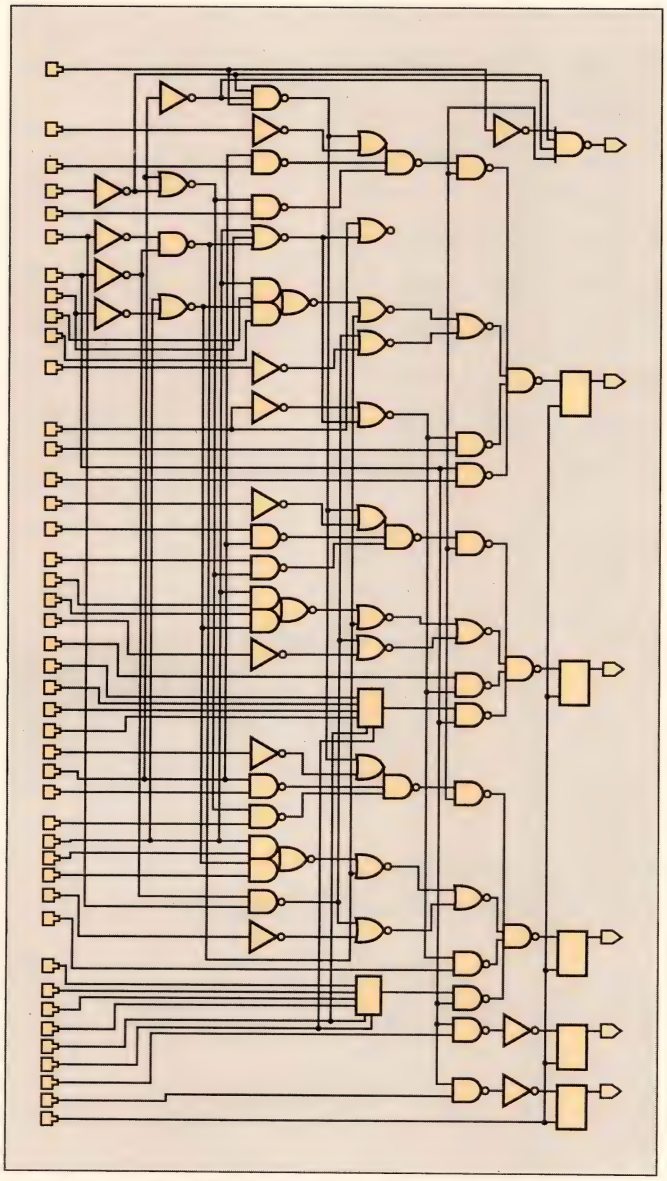


Fig 12—Optimized for the lowest possible silicon area, *this flip-flop-based interrupt controller requires 116 gate equivalents and has a 16.8-nsec delay. To speed up the design by 25% would entail doubling the gate count.*

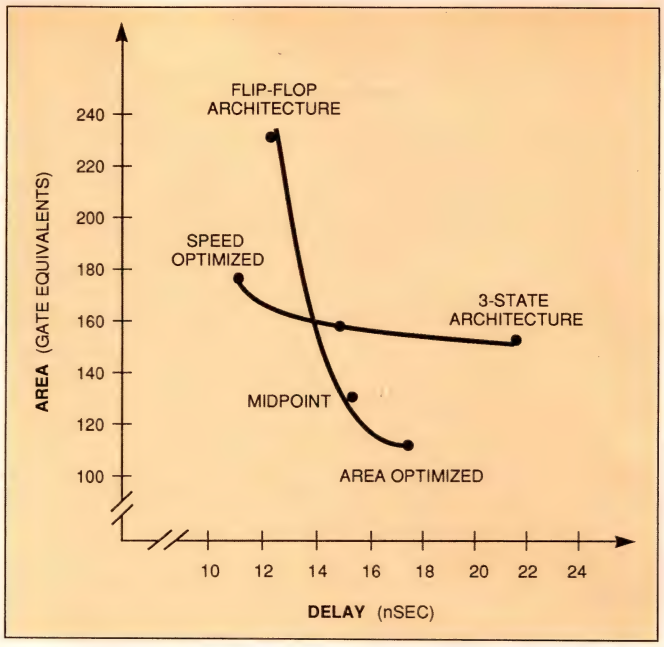


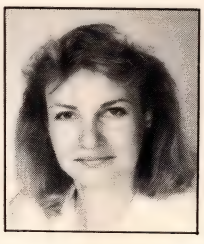
Fig 13—Tradeoffs for the two interrupt-controller architectures *are clearly discernible in these curves. The application at hand would determine the optimal type: For best silicon efficiency, the flip-flop version is the better choice; for least delay, you'd choose the 3-state structure.*

The combination of HDL design with logic synthesis provides you with an extremely powerful tool. Starting with an HDL system specification, your design group can completely specify a project with a precise, fully documented method of communication. To avoid any interface problems between the blocks, simulation of the entire set of specifications occurs before the selection of a single NAND gate. Once you conceive and document an idea, you can send an HDL description—combined with circuit-performance goals such as speed requirements, target size, and target technology—into logic synthesis and create an efficient gate-level implementation. EDN

Reference

1. Leibson, Steven, "VHDL—VHSIC hardware description language,"*EDN*, March 16, 1989, pg 110.

Author's biography



Karen Vahtra is quality-engineering manager at Synopsys Inc (Mountain View, CA), where she has worked for two years. Her job entails creating processes both within and outside her company to ensure high-quality software. Karen earned a BSEE from the University of California—Davis. In her spare time, she enjoys skiing and traveling.

Article Interest Quotient (Circle One)
High 482 Medium 483 Low 484

Our Latest Enclosure Goes In A Whole New Direction.



Your imagination needn't ever again be limited by an enclosure. Introducing the new Hoffman Designline™2 D-20 electronic enclosure with both rack and panel mounting.

The new panel mounting capability is just the first of many ways we've improved the D-20.

An economical double-wide version is now available. Multiple D-20s can be securely joined to form a single unit. Access can be made from all sides. And we've even incorporated a new disconnect capability.

This unparalleled degree of flexibility makes virtually every square inch within the cabinet usable space.

The D-20 achieves all this flexibility while providing you with the superior NEMA 12 protection you expect from Hoffman.

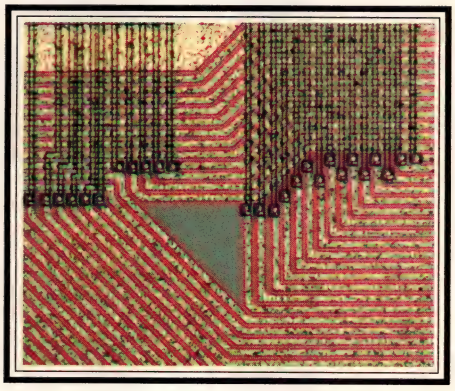
To help you discover how the D-20 can give you increased flexibility and protection, we've created a free brochure. To receive it, circle the number below or write us at 900 Ehlen Drive, Anoka MN 55303. Or call (612) 421-2240. Ask about our free Selection Software Disc, too.

CIRCLE NO. 126

Hoffman® ENGINEERING COMPANY

A Pentair Company

THIN LINES.



Line widths to 0.65 microns.

Our new state-of-the-art plant can mass-produce ULSI chips with line widths to 0.65 microns—and we can do high volume production runs on short notice. We handle ICs such as SRAMs, ROMs, and PC chip sets for PCs, workstations, disk drives, and telecommunications applications.

FAT MARGINS.



Priced for your bottom line.

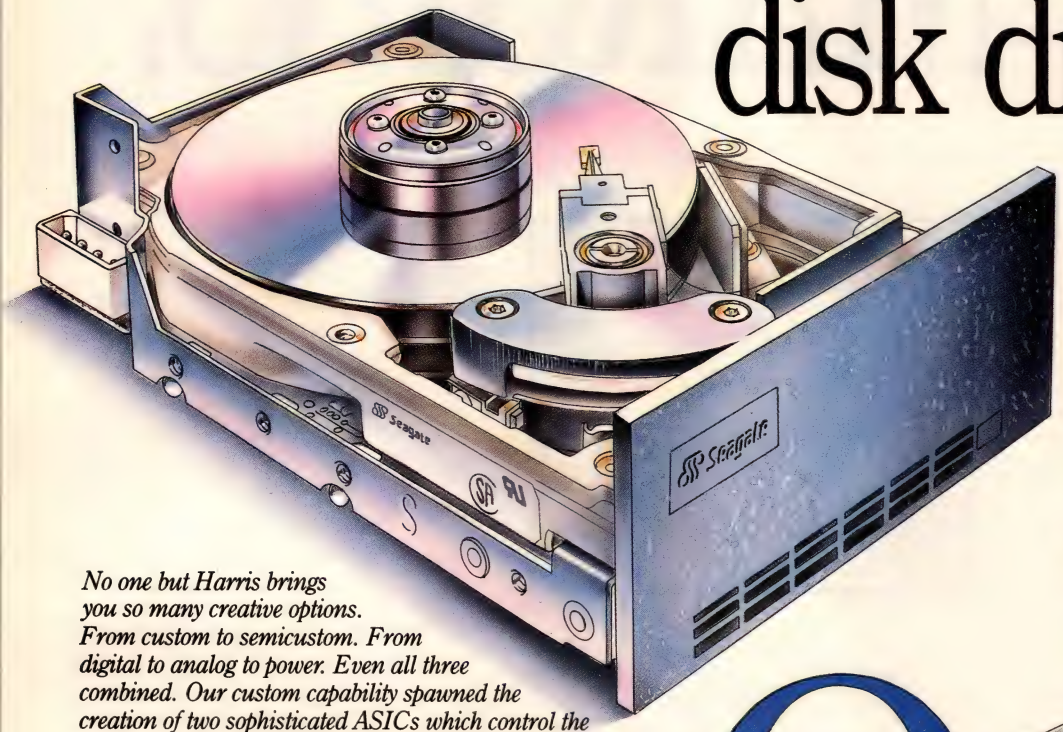
And we do all this at very, *very* attractive prices. In fact, leading manufacturers around the world buy millions of chips from us every month. If you'd like to start enjoying the benefits of thinner lines and fatter margins, call us today: 408-727-9589.

UMC

UNITED MICROELECTRONICS CORPORATION

©1990 United Microelectronics Corporation.

Harris ASICs are
disk drives to



No one but Harris brings you so many creative options. From custom to semicustom. From digital to analog to power. Even all three combined. Our custom capability spawned the creation of two sophisticated ASICs which control the motor and disk head position in this Seagate disk drive.



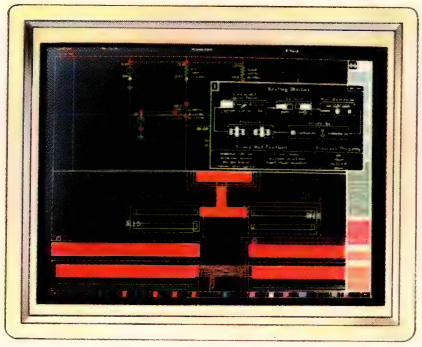
For the complexities of full custom, there's no one with more experience than Harris. Or so many processes: CMOS to BiCMOS. Bipolar JI to bipolar DI. Even BiCMOS/DMOS for Intelligent Power ASICs.



Your success is ensured because Harris is committed to total customer satisfaction. We're the number one supplier of ASICs to the U.S. military, a responsibility which sets precedents for the levels of quality, reliability and service you require.



Our broad portfolio of technologies and libraries allows for smooth integration of digital, analog and power—on a single chip. As in the mixed-signal subscriber line interface circuits we supply to major companies in the telecommunications industry.



Our FASTRACK™ Design System, built on the Cadence Framework, offers you open architecture, exceptional design flexibility, easy upgrades and a standard user interface.*



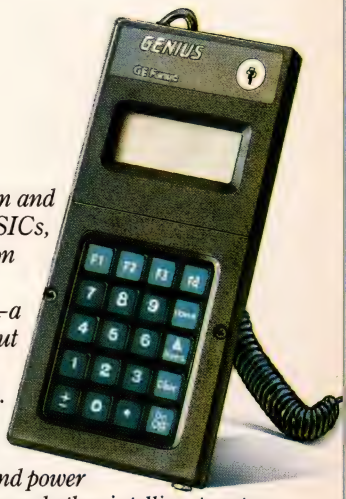
Your ASIC possibilities are enriched through our strategic alliances. Advancell®, the international agreement of Siemens, Toshiba and Harris, offers you a cell-based design library with over 400 functions, including RAM, PLA and analog. Our gate arrays include 13 sizes with up to 110,000 equivalent gates.

Harris is an unmatched source for a broad range of ASICs, including digital, analog, power, 6805 and RTX microcontrollers, and application-specific standard products. Last year alone, Harris introduced hundreds of complex new designs, now in operation in a wide variety of applications. For more information on how we can deliver your ASICs on

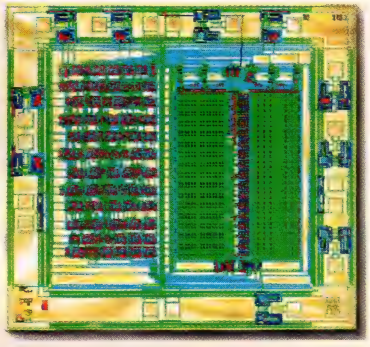
n everything from Sunday drives.



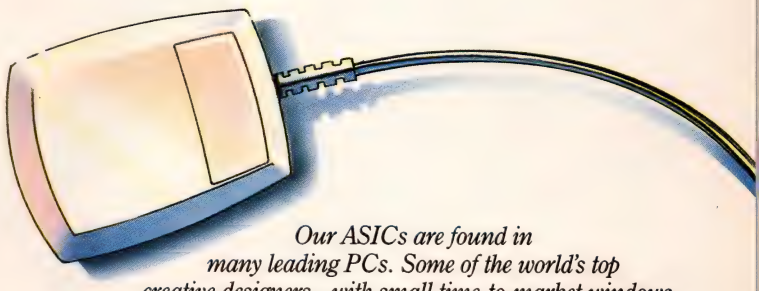
Our own ASIC design system — FASTRACK™ — isn't the only track; Harris also supports the leading industry software: Dazix, Mentor*, Valid* and OrCAD*.*



With the help of custom and off-the-shelf Harris ASICs, GE Fanuc Automation produced its unique Genius I/O System—a distributed input/output system with extensive diagnostic capabilities. Harris' wide-ranging capability lets you marry logic, analog and power for factory automation and other intelligent motor control applications.*

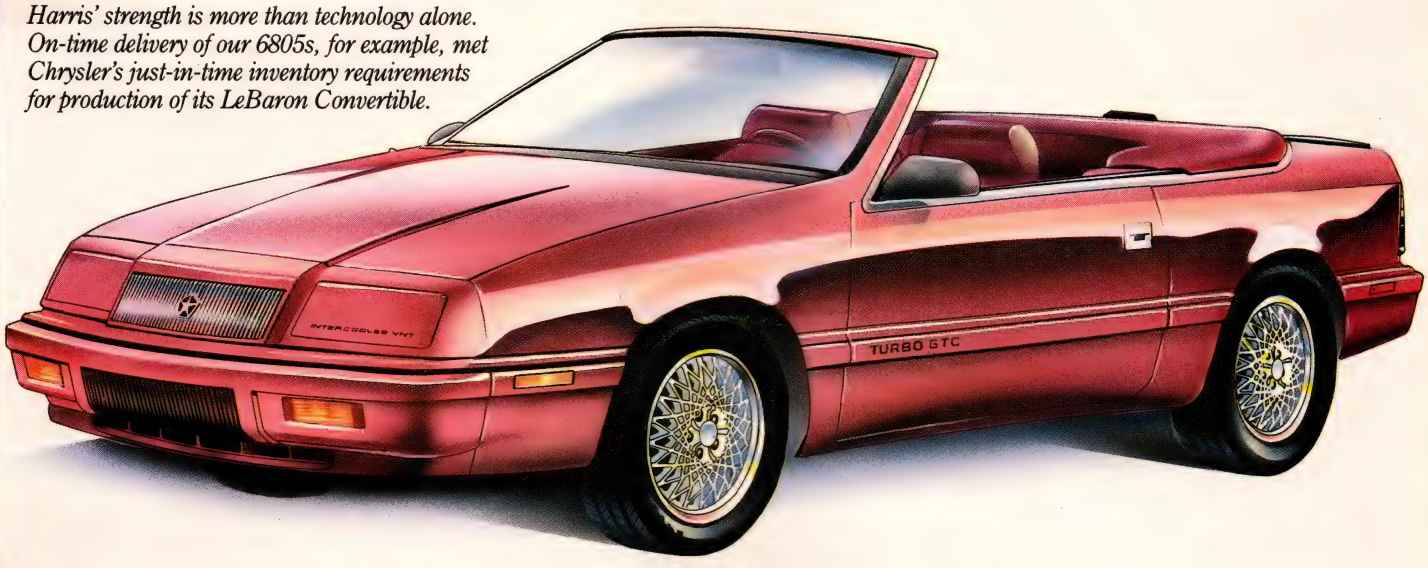


In core-based design, we support several industry standards including the 6805 and our RTX™ microcontrollers.



Our ASICs are found in many leading PCs. Some of the world's top creative designers—with small time-to-market windows—find our expertise can open doors.

Harris' strength is more than technology alone. On-time delivery of our 6805s, for example, met Chrysler's just-in-time inventory requirements for production of its LeBaron Convertible.



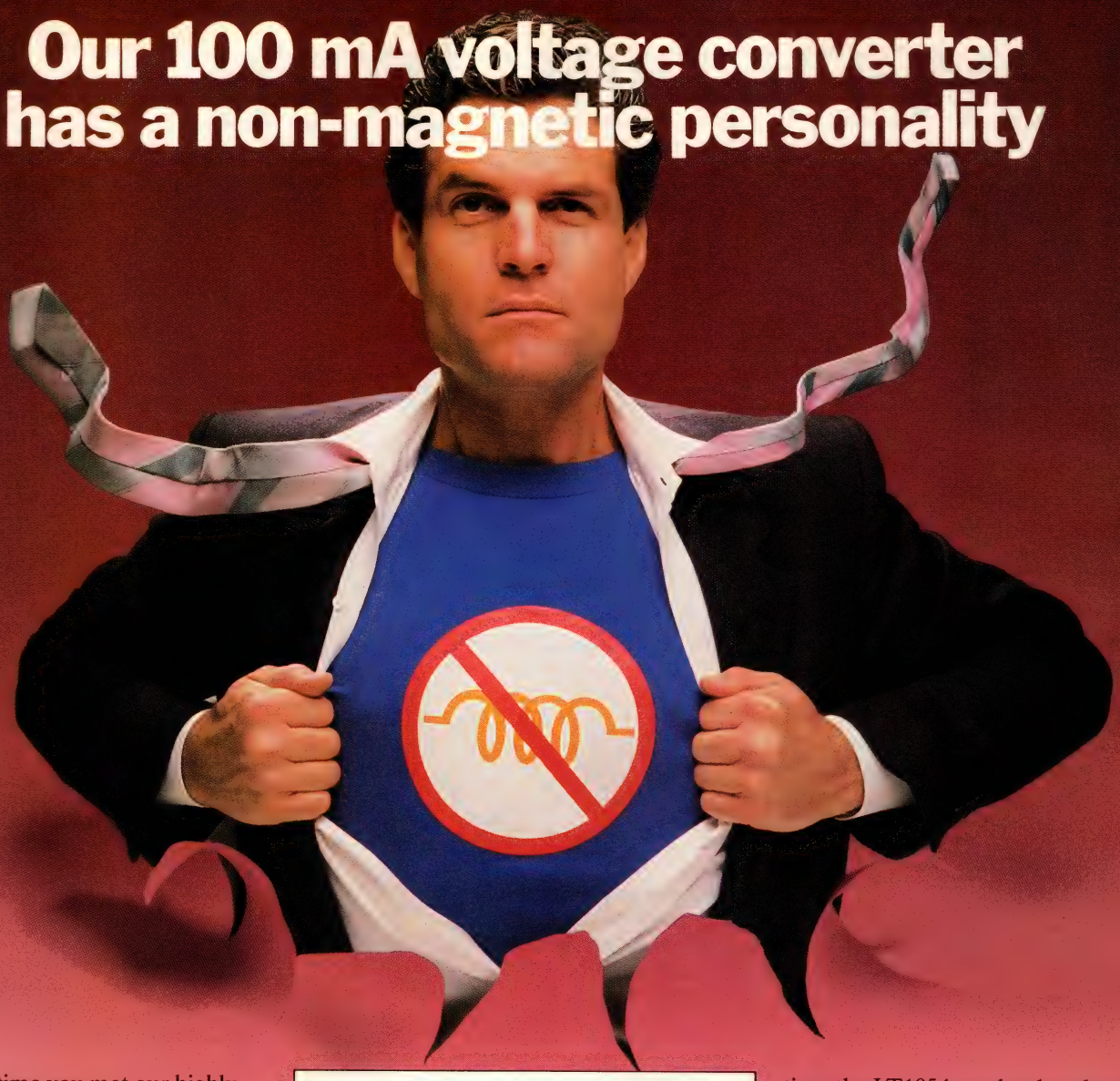
time, within budget, call 1-800-4-HARRIS, ext. 1210 (in Canada, 1-800-344-2444, ext. 1210). Or call your local sales office. Harris Semiconductor. What your vision of the future demands. Today.

HARRIS SEMICONDUCTOR
HARRIS · RCA · GE · INTERSIL

*Trademark of a company other than Harris Corporation.

CIRCLE NO. 128

Our 100 mA voltage converter has a non-magnetic personality

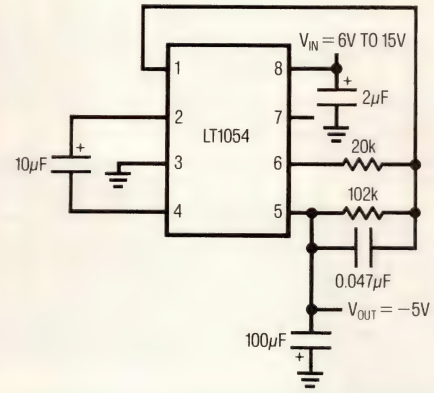


It's time you met our highly flexible LT1054 voltage converter. The bipolar LT1054 uses switched-capacitor circuitry for power conversion and requires no inductors. It has several features not previously available in voltage converters.

Power conversion functions include voltage inversion, voltage doubling or negative voltage doubling. The LT1054 can be used as a simple voltage changer or with feedback to obtain a regulated output. Only two resistors are required to set the output voltage.

The LT1054 provides roughly ten times as much output current as previous voltage converters. When used as a voltage inverter, the LT1054 can supply up to 100 mA of output current with a voltage loss of only 1.1V, and it can do this over its entire input voltage range of 3.5 to 15V. Quiescent current (I_L = OmA) is only 2.5mA. In addition, the LT1054 can be shut down, lowering quiescent current under 100μA, for battery powered applications.

Regulating Voltage Inverter



The LT1054 is ideal for use in a wide variety of applications where a supply voltage is needed that is either higher, lower, or of a different polarity than what is available.

LT1054 is pin-compatible with switched capacitor voltage converters such as LTC1044 and ICL7660, and it comes in 8-pin plastic, SOL-16 or ceramic DIP configurations. Military versions are also available.

Pricing begins at $2.95 for the 8-pin plastic LT1054CN8, $3.65 for the SOL-16 and $6.70 for the LT1054MJ8 ceramic version, in quantities of 100 up.

For technical details on the LT1054 and a free sample, contact Linear Technology Corporation, 1630 McCarthy Blvd., Milpitas, CA 95035. Or call **800-637-5545.**

LINEAR TECHNOLOGY

TOUGH PRODUCTS
FOR TOUGH APPLICATIONS.

CIRCLE NO. 129

EDITED BY CHARLES H SMALL

PLD adds hysteresis digitally

David Splitz
Codex, Mansfield, MA

The 16R8 PLD in **Fig 1** decodes the output of the ADC0803 A/D converter. The PLD energizes one of its outputs, RELAY1 through RELAY8, for a given range of the converter's output values. Because the PLD is a registered device, it can add hysteresis to each range. The two bits of hysteresis this design adds correspond to 0.039 mV of analog hysteresis. **Listing 1** is an ABLE program for the PLD. The **listing's** comment fields detail the A/D-converter ranges for each PLD output. EDN

To Vote For This Design, Circle No. 746

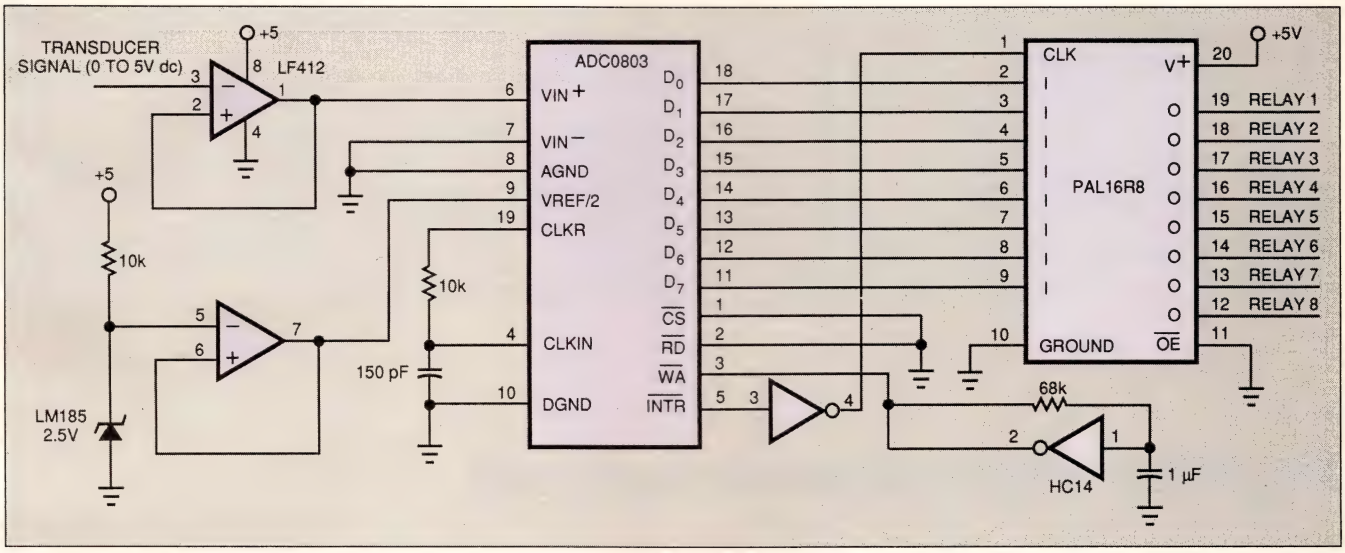


***Fig 1—The 16R8 PLD decodes the output** of the ADC0803 A/D converter and adds hysteresis.*

Listing 1—Decoder-PLD Boolean equations

```
"DEFINE DEVICE TYPE
RELAY_PAL DEVICE 'P16R8';

"DEFINE INPUT PINS
    INTR,A0,A1,A2,A3,A4,A5,A6,A7,OE
PIN 1,   2, 3, 4, 5, 6, 7, 8, 9, 11;

"DEFINE OUTPUT PINS
    RELAY0,RELAY1,RELAY2,RELAY3,RELAY4,RELAY5,RELAY6,RELAY7
PIN 19    ,18    ,17    ,16    ,15    ,14    ,13    ,12;

ADDR = [A7,A6,A5,A4,A3,A2,A1,A0];
R =    [RELAY7,RELAY6,RELAY5,RELAY4,RELAY3,RELAY2,RELAY1,RELAY0];

" THIS PAL DESIGN CAN BE USED TO PERFORM THE DECODING
" AND HYSTERESIS FUNCTIONS FOR A MONOTONIC COMPARITOR CIRCUIT

EQUATIONS

RELAY7 := !(A7 & A6 & A5 & A4                          "R7 LOW FOR ADDRESSES F0 THRU FF
   # !RELAY7 & A7 & A6 & A5 & !A4 & A3 & A2 & A1);      " ADD TWO BITS HYSTERESTIS WHEN R7 LOW

RELAY6 := !(A7 & A6 & A5 & !A4
   #  A7 & A6 & A5 & A4                          "R6 LOW FOR ADDRESSES E0 THRU FF
   # !RELAY6 & A7 & A6 & !A5 & A4 & A3 & A2 & A1);      " ADD TWO BITS HYSTERESTIS WHEN R6 LOW

RELAY5 := !(A7 & A6 & !A5
   # A7 & A6 & A5 & !A4
   # A7 & A6 & A5 & A4                            "R5 LOW FOR ADDRESSES C0 THRU FF
   # !RELAY5 & A7 & !A6 & A5 & A4 & A3 & A2 & A1);      " ADD TWO BITS HYSTERESTIS WHEN R5 LOW
```

Listing 1—Decoder-PLD Boolean equations *(continued)*

```
RELAY4 := !(A7 & !A6 & A5
   # A7 & A6 & !A5
   # A7 & A6 & A5 & !A4
   # A7 & A6 & A5 & A4                                    "R4 LOW FOR ADDRESSES A0 THRU FF
   # !RELAY4 & A7 & !A6 & !A5 & A4 & A3 & A2 & A1);       " ADD TWO BITS HYSTERESTIS WHEN R4 LOW

RELAY3 := !(A7 & !A6 & !A5
   # A7 & !A6 & A5
   # A7 & A6 & !A5
   # A7 & A6 & A5 & !A4
   # A7 & A6 & A5 & A4                                  "R3 LOW FOR ADDRESSES 80 THRU FF
   # !RELAY3 & !A7 & A6 & A5 & A4 & A3 & A2 & A1);      " ADD TWO BITS HYSTERESTIS WHEN R3 LOW

RELAY2 := !(!A7 & A6 & A5
   # A7 & !A6 & !A5
   # A7 & !A6 & A5
   # A7 & A6 & !A5
   # A7 & A6 & A5 & !A4
   # A7 & A6 & A5 & A4                                  "R2 LOW FOR ADDRESSES 60 THRU FF
   # !RELAY2 & !A7 & A6 & !A5 & A4 & A3 & A2 & A1);     " ADD TWO BITS HYSTERESTIS WHEN R2 LOW

RELAY1 := !(!A7 & A6 & !A5
   # !A7 & A6 & A5
   # A7 & !A6 & !A5
   # A7 & !A6 & A5
   # A7 & A6 & !A5
   # A7 & A6 & A5 & !A4
   # A7 & A6 & A5 & A4                                  "R1 LOW FOR ADDRESSES 40 THRU FF
   # !RELAY1 & !A7 & !A6 & A5 & A4 & A3 & A2 & A1);    " ADD TWO BITS HYSTERESTIS WHEN R1 LOW

RELAY0 := !(A7 # A6 # A5                                 " R0 LOW FOR ADDRESSES 20 THRU FF
   # !A5 & A4 & A3 & A2 & A1 & !RELAY0);                " ADD TWO BITS HYSTERESTIS WHEN R0 LOW

END HYSTERESIS_PAL
```

Regulator has common hot lead

Leonard Sherman
Maxim Integrated Products, Palo Alto, CA

The fact that its inductor is on the line side of its circuit instead of on the load side isn't the only unusual aspect of the switching-regulator circuit in **Fig 1**: the circuit's *positive* rail is common to input and output. This hookup suits some battery-powered applications.

The circuit derives 5V dc from two AA cells and can operate until the cells reach their end-of-life voltage, 1.05V (2.1V total). The circuit sips 170 µA typ, providing 5V at 4 mA while drawing 11.5 mA from a 2.1V battery. The circuit is 80% efficient.

In operation, current flows in L_1 when the regulator's (IC_1's) internal switch connects L_X, pin 5, to ground. The switch turns off after being on for approximately 10 µsec, causing the inductor to draw current from the negative output terminal through the Schottky diode, D_1. By controlling the L_X switch's period, the regulator maintains a well regulated output.

EDN

To Vote For This Design, Circle No. 747

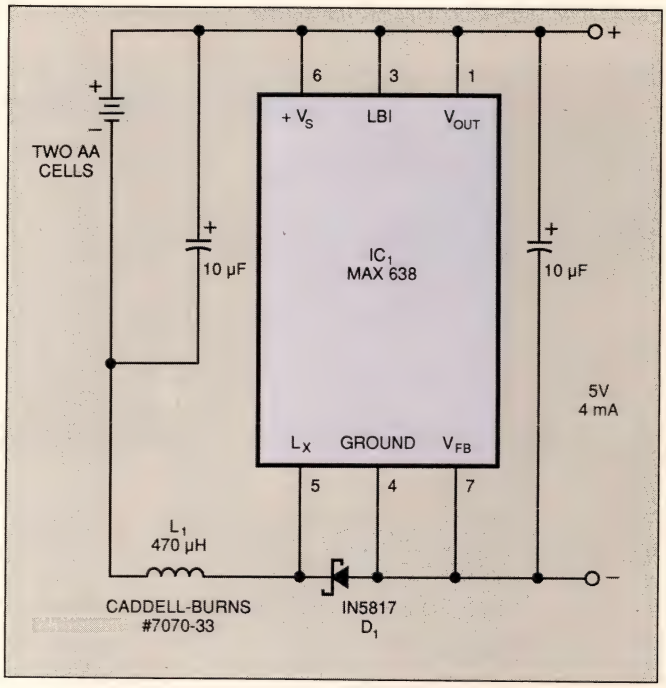


***Fig 1—This unconventional switching-regulator** circuit has a common positive terminal and delivers 5V at 4 mA from two AA cells with 80% efficiency.*

SPDT & SP4T SWITCHES

WITH BUILT-IN DRIVERS



10 to 3000MHz from $39.95

Now, high-speed, high-isolation switches with built-in drivers, tough enough to pass stringent MIL-STD-202 tests. There's no longer any need to hassle with the complexities of designing a TTL driver interface and then adding yet another component to your subsystem... it's already included in a rugged, low-cost, compact assembly. Available in the popular hermetically-sealed TO-8 package or a small EMI-shielded metal connectorized case, these tiny PIN-diode reflective switches, complete with driver, can operate over a 10 to 3000MHz span with a fast 2μsec switching speed.

Despite their small size, these units offer isolation as high as 40dB(typ), insertion loss of only 1.1dB(typ), and a 1dB compression point of +27dBm over most of the frequency range. All models are TTL-compatible and operate from a dc supply voltage of 4.5 to 5.5 V with 1.8mA quiescent current. Switch to Mini-Circuits for highest quality innovative products... and leave the driving to us.

SPECIFICATIONS

	TOSW-230 ZSDR-230		TOSW-425 ZSDR-425	
Freq. Range(MHz)	10-3000		10-2500	
Insert. Loss (dB)	typ.	max.	typ.	max.
10-100MHz	1.3	1.9	1.3	1.7
100-1500MHz	1.1	1.9	1.1	1.7
1500-3000MHz	1.8	2.7	1.8	2.5
Isolation(dB)	typ.	min.	typ.	min.
10-100MHz	60	40	60	40
100-1500MHz	40	28	40	30
1500-3000MHz	35	22	35	22
1dB Compression(dBm)	typ.	min.	typ.	min.
10-100MHz	17	6	17	6
100-1500MHz	27	19	27	19
1500-3000MHz	30	28	30	28
VSWR(ON)	typ.	max.	typ.	max.
	1.3	1.6	1.3	1.6
Switching Time (μsec) (from 50% TTL to 90% RF)	typ. 2.0	max. 4.0	typ. 2.0	max. 4.0
Oper. Temp.(°C)	-55 to +100		-55 to +100	
Stor. Temp.(°C)	-55 to +100		-55 to +100	
Price (10-24) (1-9)	**$39.95** $89.95		**$59.95** $109.95	

finding new ways ...
setting higher standards

Mini-Circuits

A Division of Scientific Components Corporation
P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500
Fax (718) 332-4661 Domestic and International Telexes: 6852844 or 620156

WE ACCEPT AMERICAN EXPRESS

CIRCLE NO. 130

F126 REV.A

PLD decodes FM data

Edward Payne
Gilbarco Inc, Greensboro, NC

The combination of the D flip-flop and 16R4 PLD in **Fig 1** separates clock signals from data in a digital-FM bit stream. This scheme is more stable and secure than designs employing a flip-flop and one-shot.

The edge-triggered flip-flop synchronizes incoming data with the PLD's clock. The PLD's clock rate is eight times the incoming bit stream's rate. When the flip-flop detects an edge in the bit stream, it presents the edge to the PLD. Upon receipt of the edge, the

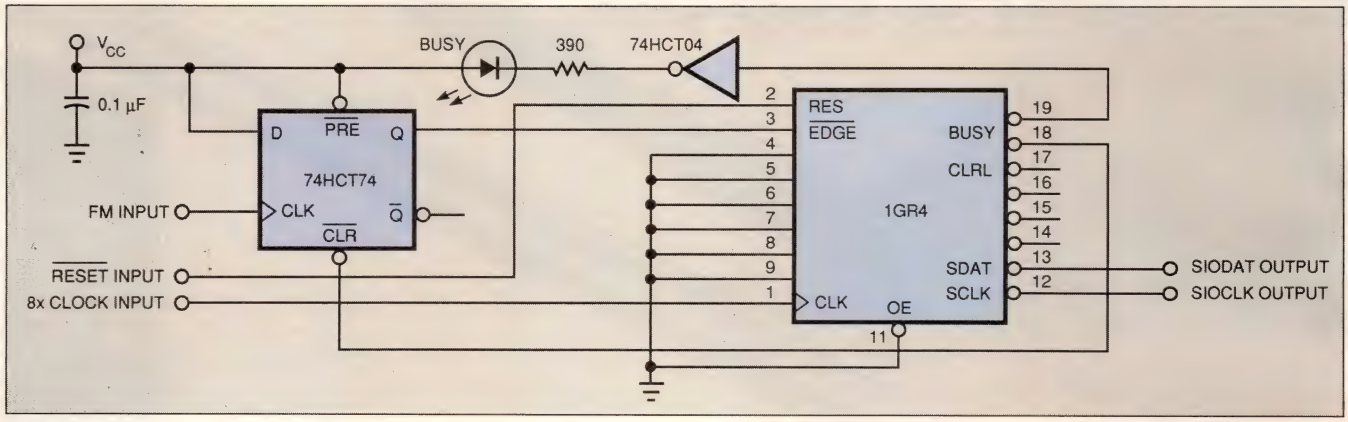


Fig 1—This circuit separates data *and clock signals from a serial bit stream using a synchronous state machine instead of a one-shot.*

Listing 1—State-machine PLD Boolean equations

```
CLK,RESET,EDGE,NC4,NC5,NC6,NC7,NC8,NC9,GND
OE,/SIOCLK,/SIODAT,/R0,/R1,/R2,/R3,/CLRLAT,/BUSY,VCC

EQUATIONS

R0 :=    /R3 * /R2 * /R1 *  R0          *  RESET ; from state  1
       + /R3 *  R2 *  R1                *  RESET ; from states 6,7
       +        R2 *  R1 *  R0 * /EDGE  *  RESET ; from states 7,F
       +  R3 *  R2 * /R1       * /EDGE  *  RESET ; from states C,D
       +  R3                   *  EDGE  *  RESET ; from states 8,9,A,B,C,D,E,F
       +       /R2 * /R1       *  EDGE  *  RESET ; from states 0,1,8,9

R1 :=    R3                     *  EDGE  *  RESET ; from states 8,9,A,B,C,D,E,F
       +       R2 *  R1         *  EDGE  *  RESET ; from states 6,7,E,F
       +       R2 *  R1 * /R0           *  RESET ; from states 6,E
       +  R3       *  R1       * /EDGE  *  RESET ; from states A,B,E,F
       +  R3 *  R2         *  R0 * /EDGE  *  RESET ; from states D,F
       +       /R2 *  R1 *  R0           *  RESET ; from states 3,B

R2 :=    R3               * /R0 * /EDGE  *  RESET ; from states 8,A,C,E
       +       R2 * /R1 *  R0 * /EDGE  *  RESET ; from states 5,D
       + /R3 *  R2 * /R1 *  R0          *  RESET ; from state  5
       + /R3 *  R2 *  R1       * /EDGE  *  RESET ; from states 6,7

R3 :=    /R3 * /R2 * /R1 *  R0          *  RESET ; from state  1
       +  R3 * /R2                * /EDGE  *  RESET ; from states 8,9,A,B
       +  R3       * /R1          * /EDGE  *  RESET ; from states 8,9,C,D
       +  R3               *  R0 * /EDGE  *  RESET ; from states 9,B,D,F

SIOCLK =  R3
       +              R1 * /R0
       +       /R2 * /R1
       +        R2         *  R0

SIODAT = /R3        * /R1

CLRLAT = /R3 * /R2         *  R0

BUSY   = /R3 * /R2 * /R1 * /R0
```

MULTIPORT VIDEO RAM ELIMINATES SCREEN BOTTLENECK IN PC's AND WORKSTATIONS

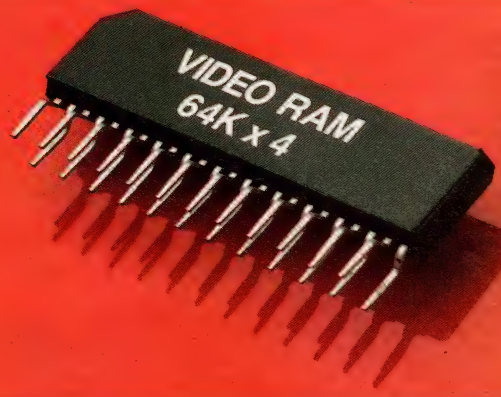


Goldstar's new 64K x 4 multiport Video RAM provides a cost-effective way for designers of computer graphics boards and systems to eliminate the bottleneck between screen update and screen refresh functions. With dual-port accessibility, bidirectional data transfer, bit-masked write function—this multiport RAM is optimized for use in PC graphics, CAD/CAE workstations, and other applications requiring high-speed serial access of data.

This industry-standard device integrates two read/write memories: one 256 x 4 serial access memory (SAM), and one 64K x 4 DRAM, which can operate independently. In a typical application, the CPU performs update operations on the DRAM while the SAM serially transfers pixel information to the monitor—significantly improving performance in bit-mapped graphics systems.

The Goldstar Video RAM is available now through the company's North American network of representatives and distributors. It is offered in the industry standard plastic zig-zag in-line "Zip" package, which provides the space-saving characteristics needed for high-device-density boards.

For more information, contact:
Semiconductor Marketing,
Goldstar Technology, Inc.,
3003 North First Street,
San Jose, California 95134-2004.
Phone: (408) 432-1331.
FAX: (408) 432-6053



VIDEO RAM	
Part Number:	GM53C261/461
Description:	64K x 4 CMOS
Access Times:	80/100/120ns
Power Supply Current:	85mA
Package:	24 ZIP

GoldStar
GOLDSTAR TECHNOLOGY INC.

CIRCLE NO. 131

PLD traverses the state machine shown in **Fig 2.**

The PLD first enters state 1 and then goes through a timing chain of 10 Gray-coded states. This timing chain, along with states 0 and 1, consumes 75% of the bit-stream's period. If the PLD detects no additional edges during this period, it clocks a zero out of its serial-data output via states 3, 2, and 0.

If however, an additional edge occurs, the PLD exits its timing chain, clears its latch, and clocks a one out of its serial-data output via states 3, 2, and 0.

The PLD's output equations in **Listing 1** specify that the serial-data output is valid both before and after the clock-pulse output (SIOCLK) for race immunity and to allow either a positive or negative edge-triggered receiver without reprogramming the PLD. The PLD also provides a BUSY output to energize a status LED. EDN

To Vote For This Design, Circle No. 748

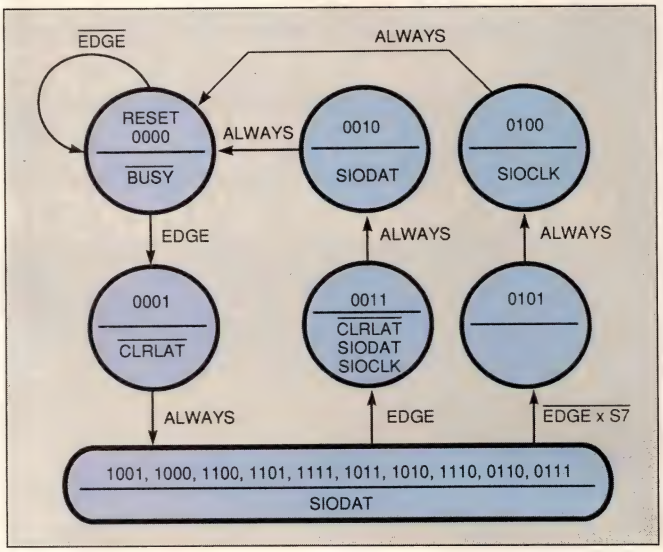


***Fig 2—This state machine, running at eight times** the incoming data's rate, includes a Gray-coded timing chain.*

Circuits kill storage delays

Robert V Dvorak
FTS Systems, Stone Ridge, NY

The circuits in **Fig 1** can substantially reduce bipolar power transistors' turn-off delays arising from base-charge storage. In **Fig 1a,** L_1 will continue to conduct after the switch opens. If L_1 can store enough energy to forward-bias Q_2, then Q_2 will dump Q_1's base charge to the V^- rail until L_1's field decays. When Q_1's base charge is dumped, any remaining turn-off delay is a combination of the rise time of Q_2, the delay time of Q_1, and miscellaneous effects, such as the rise time of your scope. **Fig 1a**'s circuit consumes no steady-state power.

Using a 2N3725 for Q_1 with a 0.5A collector current, Q_1's base current, I_B, is therefore 30 mA. If L_1's inductance is 2.7 μH, and Q_2 is a 2N5771, then the circuit's overall turn-off time measures 5 nsec. This value bests the 40-nsec delay of a conventional circuit.

You'll have to size the circuit's component values to suit your power transistor and current levels. Q_2 should be a high-speed amplifier, optimized for rapid turn-on, and must conduct the potentially high current pulse from Q_1's base. D_1 should be a high-speed signal diode, such as a 1N914. R_1 is a high-value device that bleeds

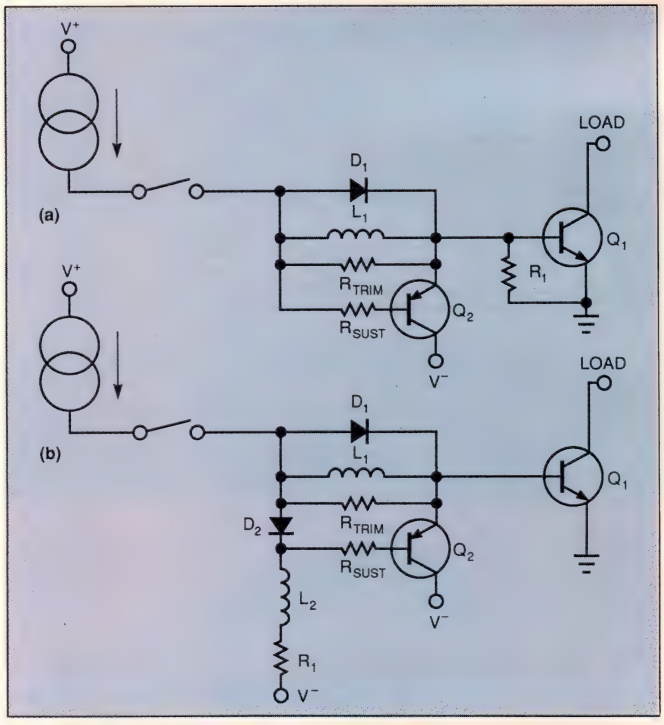
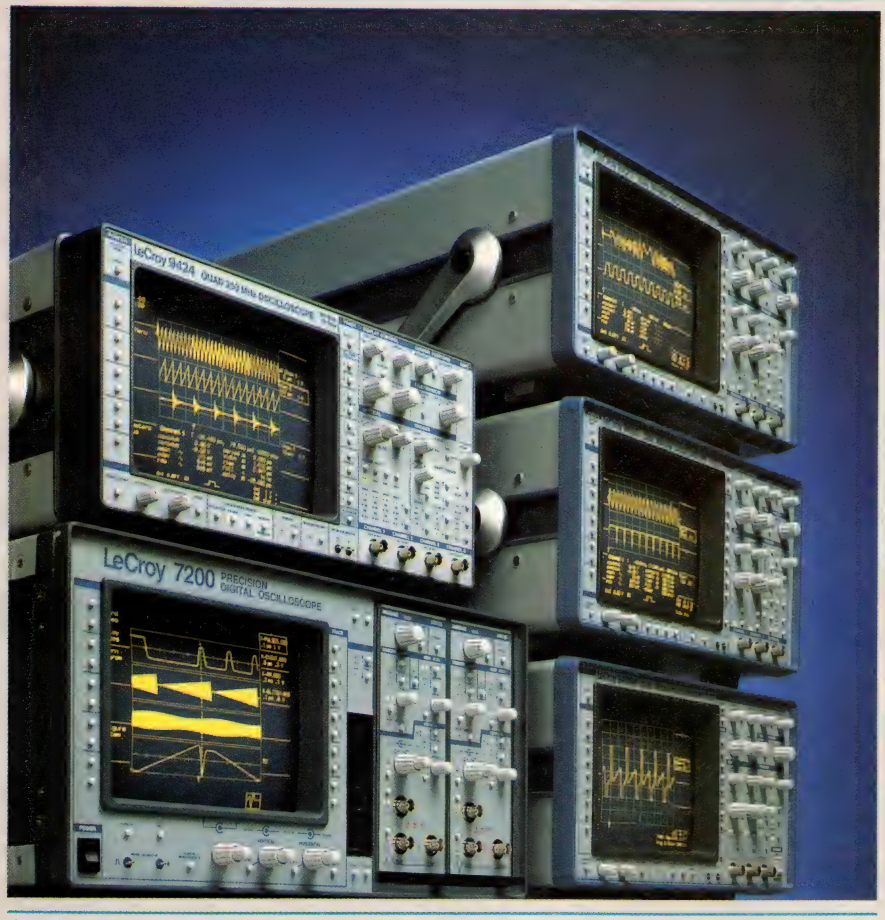


***Fig 1—These circuits speed the turn-off** of a saturated power transistor by shunting its base charge to ground. The circuit in **a** performs well as high as 5 MHz. and **b** is a better choice above this frequency.*

NO MORE COMPROMISES!



Not all oscilloscope users are comfortable with layered menus, 6-bits, fuzzy screens, low single shot bandwidth, limited expansion, slow display updates, and short waveform memories that you're often expected to accept in digital oscilloscopes.

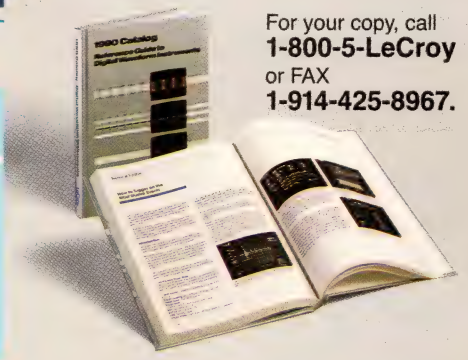
If what you want is a DSO that acts and feels like an analog scope, plus has easy measurement, storage, and glitch catching capabilities, then perhaps it's time you looked at LeCroy.

Let us prove it! Request our 272-page hardcover "Reference Guide to Digital Waveform Instruments" for an armchair view of our complete line of digital scopes and other T&M instruments. It explains how long memories, vector-type displays, resolution to 11 bits, SMART trigger, innovative signal processing, and mass storage are utilized to make instruments which really ARE better, without being hard to use.

It's Time You Looked at LeCroy!

Choose from these options, and more.

Model	No. of Channels	Sampling Rate	Memory Length	Analog Bandwidth
9450	2	400 MS/s	50 K	350 MHz
9424	4	100 MS/s	50 K	350 MHz
9420	2	100 MS/s	50 K	350 MHz
9400A	2	100 MS/s	32 K	175 MHz
7200/4	4	1 GS/s	50 K	400 MHz
7200/2	2	1 GS/s	50 K	400 MHz



For your copy, call
1-800-5-LeCroy
or FAX
1-914-425-8967.

700 CHESTNUT RIDGE ROAD, CHESTNUT RIDGE, N.Y. 10977

LeCroy

Innovators in Instrumentation

off leakage currents in the off state. L_1 usually is only a few microhenrys, perhaps a few turns of thin wire through a ferrite bead.

Fig 1a's circuit performs well up to frequencies of 5 MHz. Above this frequency, use the circuit in **Fig 1b.** Here, R_1 and L_2 provide the current to Q_2, at the cost of additional components and a small power dissipation in the on state. D_2, in addition to the dc voltage on L_1, maintains the off bias of Q_2 while Q_1 is normally on. In some cases, you may have to add some series resistance.

When the power transistor's base current stops, L_2 continues to conduct, turning on Q_2. L_1 reverse-biases D_2 and diverts the R_1's and L_2's current to Q_2.

If you reverse the diodes, you can substitute pnp devices for the circuits' npn devices. EDN

To Vote For This Design, Circle No. 749

PLD processes pixels pronto

Shazeb J Rathore
Technical Communications Corp, Concord, MA

The 20L8 PLD in **Fig 1** modifies pixels coming from a frame buffer in real time. The PLD modifies the pixel according to directions from the mode-control register. This Design Idea describes only the pixel-modifying PLD—not the frame buffer, display circuitry, or mode-control register.

The PLD modifies the pixels in the following ways:

- Image only. Plain image with no processing.
- Translucent. Some image with the background color showing through.
- Half opaque. Color only, with half intensity.
- Opaque. Color only, with half intensity.
- EXOR. EXOR the pixel with a color or background.

Table 1 shows the PLD's pin assignments, and **Listing 1** contains the PLD's Boolean equations. EDN

To Vote For This Design, Circle No. 750

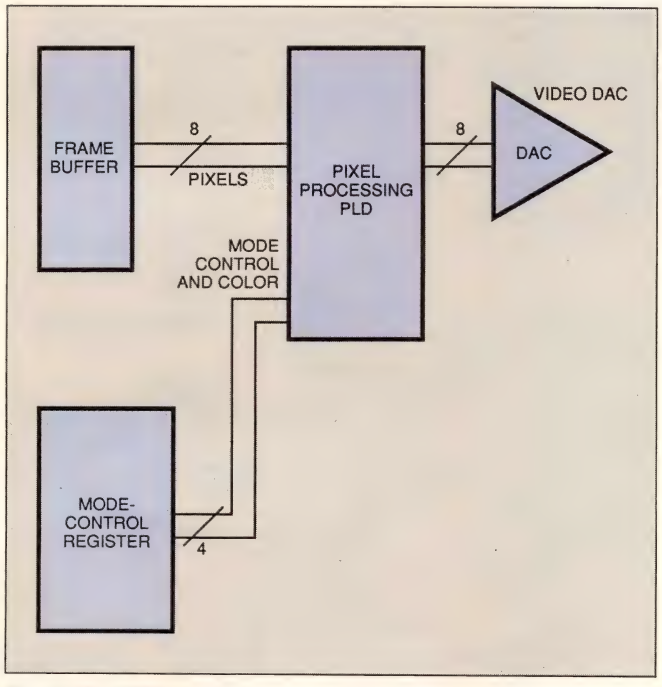


***Fig 1—The PLD in this circuit** modifies pixels from a frame buffer on their way to a display circuit.*

Table 1—PLD pin assignments

Name	Function	Comments
M1	Input	Mode control bit 1
M2	Input	Mode control bit 2
M3	Input	Mode control bit 3
CL	Input	Color bit, used for colored system
I0	Input	Pixel bit 1
I1	Input	Pixel bit 2
I2	Input	Pixel bit 3
I3	Input	Pixel bit 4
I4	Input	Pixel bit 5
I5	Input	Pixel bit 6
I6	Input	Pixel bit 7
I7	Input	Pixel bit 8
$\overline{D0}$	Output	Pixel bit 1, to DAC
$\overline{D1}$	Output	Pixel bit 2, to DAC
$\overline{D2}$	Output	Pixel bit 3, to DAC
$\overline{D3}$	Output	Pixel bit 4, to DAC
$\overline{D4}$	Output	Pixel bit 5, to DAC
$\overline{D5}$	Output	Pixel bit 6, to DAC
$\overline{D6}$	Output	Pixel bit 7, to DAC
$\overline{D7}$	Output	Pixel bit 8, to DAC

Listing 1—PLD Boolean equations

```
M1,M2,M3                pin 1,2,3;
I0,I1,I2,I3             pin 4,5,6,7;
I4,I5,I6,I7             pin 8,9,10,11;
CL                      pin 13;

!D0,!D1,!D2,!D3         pin 15,16,17,18;
!D4,!D5,!D6,!D7         pin 19,20,21,22;

inputa = [M1,M2,M3];
inputb = [I0,I1,I2,I3,
          I4,I5,I6,I7];
inputc = [CL];

output = [!D0,!D1,!D2,!D3,!D4,!D5,!D6,!D7];


equations

D7    =  !M3 & !M2 & !M1 &  CL &  I7      " Image only
      #  !M3 & !M2 &  M1 &  CL           " Translucent
      #   M3 &  M2 &  M1 &  CL           " Opaque
      #   M3 & !M2 &  M1 &  CL & !I7     " EXOR with color
      #   M3 & !M2 &  M1 & !CL &  I7   ; " EXOR with color
                                         " 1/2 opaque


D6    =  !M3 & !M2 & !M1 &  CL &  I6      " Image only
      #  !M3 & !M2 &  M1 &  CL &  I7     " Translucent
      #  !M3 &  M2 & !M1 &  CL           " 1/2 Opaque
      #   M3 &  M2 &  M1 &  CL           " Opaque
      #   M3 & !M2 &  M1 &  CL & !I6     " EXOR with color
      #   M3 & !M2 &  M1 & !CL &  I6   ; " EXOR with color


D5    =  !M3 & !M2 & !M1 &  CL &  I5      " Image only
      #  !M3 & !M2 &  M1 &  CL &  I6     " Translucent
      #  !M3 &  M2 & !M1 &  CL           " 1/2 Opaque
      #   M3 &  M2 &  M1 &  CL           " Opaque
      #   M3 & !M2 &  M1 &  CL & !I5     " EXOR with color
      #   M3 & !M2 &  M1 & !CL &  I5   ; " EXOR with color


D4    =  !M3 & !M2 & !M1 &  CL &  I4      " Image only
      #  !M3 & !M2 &  M1 &  CL &  I5     " Translucent
      #  !M3 &  M2 & !M1 &  CL           " 1/2 Opaque
      #   M3 &  M2 &  M1 &  CL           " Opaque
      #   M3 & !M2 &  M1 &  CL & !I4     " EXOR with color
      #   M3 & !M2 &  M1 & !CL &  I4   ; " EXOR with color

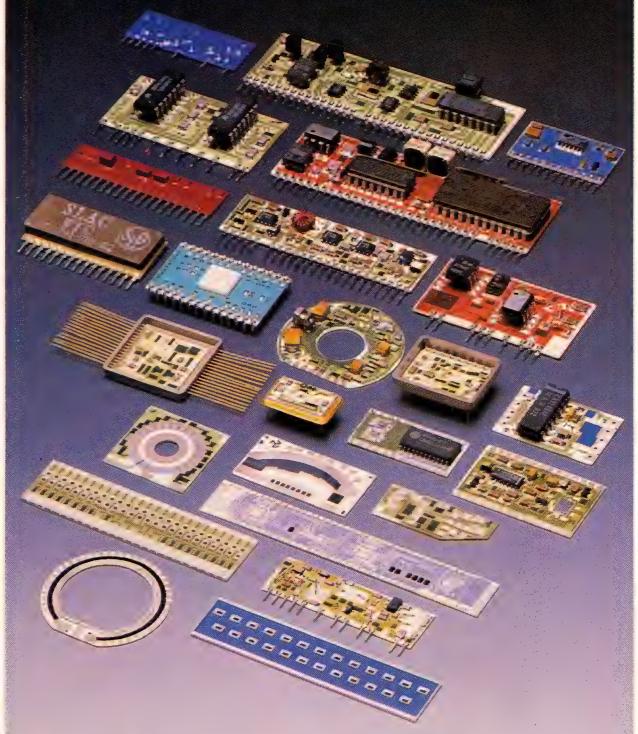

D3    =  !M3 & !M2 & !M1 &  CL &  I3      " Image only
      #  !M3 & !M2 &  M1 &  CL &  I4     " Translucent
      #  !M3 &  M2 & !M1 &  CL           " 1/2 Opaque
      #   M3 &  M2 &  M1 &  CL           " Opaque
      #   M3 & !M2 &  M1 &  CL & !I3     " EXOR with color
      #   M3 & !M2 &  M1 & !CL &  I3   ; " EXOR with color


D2    =  !M3 & !M2 & !M1 &  CL &  I2      " Image only
      #  !M3 & !M2 &  M1 &  CL &  I3     " Translucent
      #  !M3 &  M2 & !M1 &  CL           " 1/2 Opaque
      #   M3 &  M2 &  M1 &  CL           " Opaque
      #   M3 & !M2 &  M1 &  CL & !I2     " EXOR with color
      #   M3 & !M2 &  M1 & !CL &  I2   ; " EXOR with color


D1    =  !M3 & !M2 & !M1 &  CL &  I1      " Image only
      #  !M3 & !M2 &  M1 &  CL &  I2     " Translucent
      #  !M3 &  M2 & !M1 &  CL           " 1/2 Opaque
      #   M3 &  M2 &  M1 &  CL           " Opaque
      #   M3 & !M2 &  M1 &  CL & !I1     " EXOR with color
      #   M3 & !M2 &  M1 & !CL &  I1   ; " EXOR with color


D0    =  !M3 & !M2 & !M1 &  CL &  I0      " Image only
      #  !M3 & !M2 &  M1 &  CL &  I1     " Translucent
      #  !M3 &  M2 & !M1 &  CL           " 1/2 Opaque
      #   M3 &  M2 &  M1 &  CL           " Opaque
      #   M3 & !M2 &  M1 &  CL & !I0     " EXOR with color
      #   M3 & !M2 &  M1 & !CL &  I0   ; " EXOR with color
```

LOWER COSTS, REDUCE SIZE & INCREASE RELIABILITY



By using thick film hybrid technology, we can convert your circuit schematics or existing PC board circuits into more compact and reliable modules. Hybrid packaging not only provide space reduction, but also eliminates the the hassel of ordering testing, stocking and assembling components.

Reliability of the entire system is enhanced due to fact that hybrid modules have fewer discrete components and fewer connections. We provide metalized ceramic substrates as well as the complete hybrid modules at reasonable cost and with quick delivery.

To meet your requirements in reliability, resucing size and handling costs, contact us for more information.

th ELECTRONICS

TONG HSING ELECTRONIC INDUSTRIES, LTD.

Head Office
4F, 85 Yenping, Rd. S,
Taipei, Taiwan R.O.C.
Tel: 886-2-679-0122
Telex: 11282 TONHSIN
Fax: 886-2-361-6670

U.S. Office
31 East 400 South Orem, UT
84058 U.S.A.
Tel: 801-226-1383
Telex: 453161 EPHYCERAM
Fax: 801-226-1437

CIRCLE NO. 134

DESIGN IDEAS

FEEDBACK AND AMPLIFICATION

Motor drive runs in one direction

V Lakshminarayanan's Design Idea, "PLD adds flexibility to motor controller," on pg 177 of the March 1, 1990, edition of EDN, has major problems. The stepper-motor controller's timing generator in **Table 1** does not show the actual states and next states of the inputs for the motor in the counter-clockwise direction or which outputs are actually on in that direction. The Sprague Electric UCN-5804B motor-controller IC does the job the Design Idea covers, and it runs in both directions.

Joseph M Lopez, Product Engineer
Sprague Electric Co
115 Northeast Cutoff
Worcester, MA 01615

Arbiter expansion accrues typos

I made several typos in my Design Idea, "PLD expands arbiter chip" (EDN, January 8, 1990, pg 178). The best way to resolve them is to remove all the inversion bars from the equations and from the bus-grant outputs. Also, references to the 74F789 should be to the 74F786.

Ted Burton
Signetics
1275 S 800 E, M/S D7
Orem, UT 84058
(801) 225-6600, ext 4207

DI provides spark to reset 8031

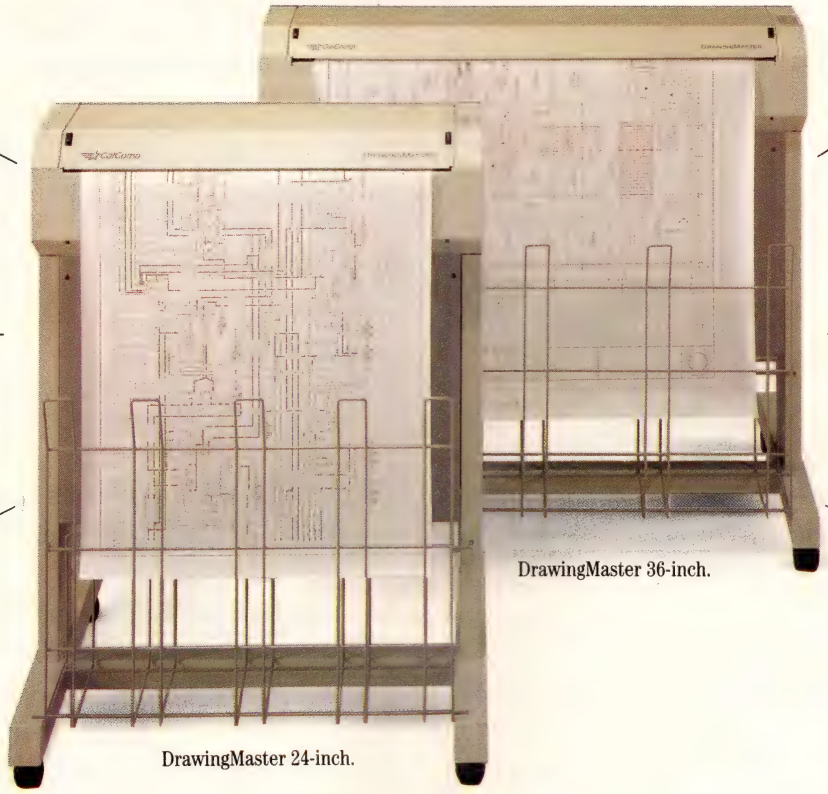
Embedded single-chip-μP software must tolerate a host of harsh and alien environments. In the event of trouble, most systems reset the single-chip μP as a last resort. Yet you can't always assume that your single-chip μP has been properly reset.

Recently, I was testing a device with an embedded 8031 single-chip μP for resistance to power transients. My tests would drop out the power supply briefly. Unfortunately, short transients would not generate a complete 8031 reset, and the device would hang. The most obvious symptom of hanging was the loss of serial communication.

Rather than modifying the device's hardware to achieve a glitch-free power supply, I decided to try a software fix. I determined that because the power transient was resetting the single-chip μP's program counter to zero, some sort of partial reset was occurring.

I attempted to mimic the single-chip μP's built-in

Mean, Clean, Plotting Machines.



Plot or plod. It's your choice.

The same plots that take hours on pen plotters will roll off a DrawingMaster® direct imaging plotter in just minutes.

Simple plots take just seconds.

DrawingMaster even out-plots monochrome electrostatics and lasers plus you get two colors–black and red.

That's at DrawingMaster's normal 200 x 200 dpi.

Two other operation modes allow you to optimize DrawingMaster to your specific needs.

QuickPlot® almost doubles plotting speed for fast checkplots at 200 x 100 dpi.

QualPlot® boosts resolution to 400 x 200 dpi.

Whatever mode, these are mean machines.

And clean? DrawingMaster uses no pens, no toner, no ribbons and no chemicals. No kidding.

You simply load a roll of paper or film and plot. With a full roll, DrawingMaster can produce more than 50 E-sized plots unattended.

Plot quality is outstanding. CalComp's high-contrast premium DirectWrite® paper is ideal for diazo and photo reproductions and it's specially formulated for long-term stability and archiving.

DrawingMaster. It's mean. It's clean. Shouldn't it be your next plotting machine?

For more information, call **800-CALCOMP.** In Canada, 416-635-9010. Or write: CalComp, P.O. Box 3250, Anaheim, CA 92803. We're expecting to hear from you.

We draw on your imagination.™

CalComp
A Lockheed Company

©1990 CalComp Inc. DrawingMaster, QuickPlot, QualPlot, DirectWrite and We draw on your imagination are trademarks or registered trademarks of CalComp Inc.

Design Entry Blank

$100 Cash Award for all entries selected by editors. An additional $100 Cash Award for the winning design of each issue, determined by vote of readers. Additional $1500 Cash Award for annual Grand Prize Design, selected among biweekly winners by vote of editors.

To: Design Ideas Editor, EDN Magazine
Cahners Publishing Co
275 Washington St, Newton, MA 02158

I hereby submit my Design Ideas entry.

Name _____

Title _____ Phone _____

Company _____

Division (if any) _____

Street _____

City _____ State _____

Country _____ Zip _____

Design Title _____

Home Address _____

_____

Social Security Number _____
(Must accompany all Design Ideas submitted by US authors)

Entry blank must accompany all entries. Design entered must be submitted exclusively to EDN, must not be patented, and must have no patent pending. Design must be original with author(s), must not have been previously published (limited-distribution house organs excepted), and must have been constructed and tested.

Exclusive publishing rights remain with Cahners Publishing Co unless entry is returned to author or editor gives written permission for publication elsewhere.

In submitting my entry, I agree to abide by the rules of the Design Ideas Program.

Signed _____

Date _____

ISSUE WINNER

The winning Design Idea for the March 1, 1990, issue is entitled "Frame-grabber PLL integrates controller," submitted by Luis de Sa and Vitor Silva of University of Coimbra (Coimbra, Portugal).

Your vote determines this issue's winner. All designs published win $100 cash. All issue winners receive an additional $100 and become eligible for the annual $1500 Grand Prize. **Vote now**, by circling the appropriate number on the reader inquiry card.

FEEDBACK AND AMPLIFICATION

reset function by adding software that set all of the single-chip μP's special-function registers to the reset values listed in its manual. But the new software didn't work; the device still hung up. The question was, what else does the single-chip μP's built-in reset function do?

The Design Idea, "Routine interrupts interrupts," (EDN, June 8, 1989, pg 207) provided the answer. The built-in reset also resets the single-chip μP's internal interrupt logic. My problem was that my partial reset could occur while the single-chip μP was servicing a serial-communications interrupt. So even though the partial reset zeroed the program counter, and my new software reset the special-function registers and reenabled interrupts, the previous serial-communications interrupt was still pending.

Changing the return (RET) instruction at the end of my new software to a return-from-interrupt (RETI) instruction cleared up my problem.

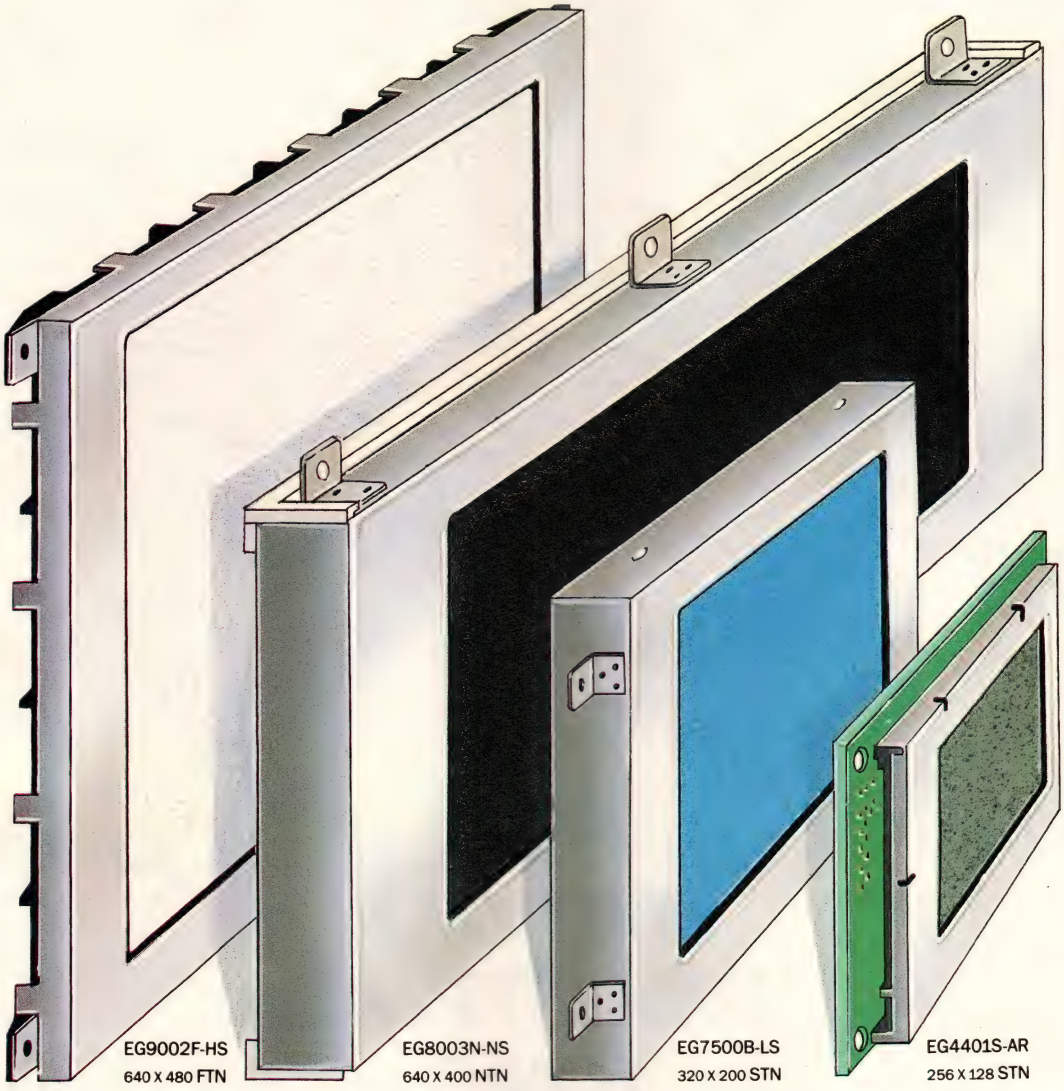
Jeremy Ottenstein, Software Engineer
Bendix Flight Systems
Rte 46
Teterboro, NJ 07608
(201) 288-2000, ext 4733

New EDN computer bulletin board to feature Design Ideas

Design Ideas and related material will feature prominently in EDN's new computer bulletin board. First, you will be able to download copies of all software, such as programs and Boolean equations for PLDs, from the EDN bulletin board. No longer will you have to write to the Design Idea's author to get a copy of a software-related Design Idea or enter it by hand from a listing printed in EDN. Second, we encourage all faithful readers of the section to post comments, corrections, or enhancements to Design Ideas on our EDN bulletin board. We, in turn, will monitor the bulletin board faithfully and reprint the best entries here in this column.—Charles H Small and Anne Watson Swager EDN

SOLUTIONS IN PERFECT PROPORTION

FROM EPSON OEM



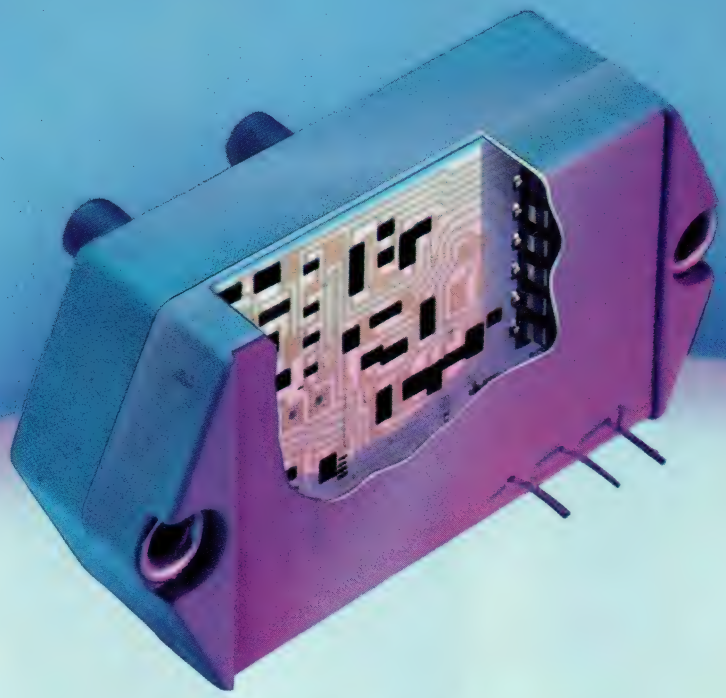
From large VGA resolution LCD MODULES to small alphanumeric displays, Epson has a solution in perfect proportion for your newest product application. The EG series of graphics display panels are available in 92 configurations ranging from 640 X 480 dots to 128 X 64 dots. A choice of super-twisted STN, page-white NTN or the latest in single film FTN technologies provides high-contrast and wide-angle viewing that rival the more traditional CRT. The popular EA-D series of alphanumeric modules come in 8 sizes from two lines of 40 characters to one line of 16 characters with a choice of EL or LED backlighting. Featuring low power consumption and unique chip-on-flex drivers in a compact, lightweight design Epson LCDs are ideal for applications ranging from handheld and laptop computers to point-of-sale displays and telecommunications terminals. For additional product information and detailed specifications, please contact your nearest Epson OEM sales office.

EPSON AMERICA, INC
OEM DIVISION

San Francisco 408/257-6730 ■ Los Angeles 714/768-7474 ■ Chicago 815/455-7630 ■ Atlanta 404/552-1150
Boston 617/245-8007 ■ Vancouver 604/421-8008 ■ Toronto 416/479-8866 ■ Montreal 514/331-7534

HAWKER

Advanced Pressure Sensors



FOR:
MEDICAL
INDUSTRIAL
HVAC

Sensym's 142/163 Series

Features Include:

- Guaranteed precision over temperature: ±1% Max (−18°C to +63°C)!
- High level calibrated output: 1.0V ±50mV offset 5.0V ±50mV span
- Linearity: <0.75% FSO Max

These precision transducers are priced starting at **$40 ea/ 100's. Stock delivery.**

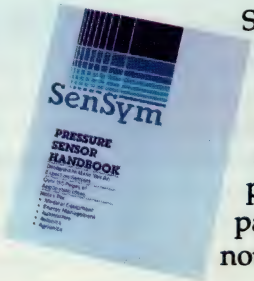
Available parts:

163SC01D48 ... −20 to +120cmH_2O

142SC series .. 0 to 1psi up to 0 to 150psi

HAWKER SIDDELEY
SenSym
SOLID STATE SENSORS

Free Handbook



Sensym's new 1990 Sensor Handbook gives complete product specifications plus over 200 pages of application notes and ideas.

Call or fax us today for your free Sensor Handbook.

CIRCLE NO. 137

1244 Reamwood Avenue ■ Sunnyvale, CA 94089 ■ Tel: (408) 744-1500 ■ Fax: (408) 734-0407

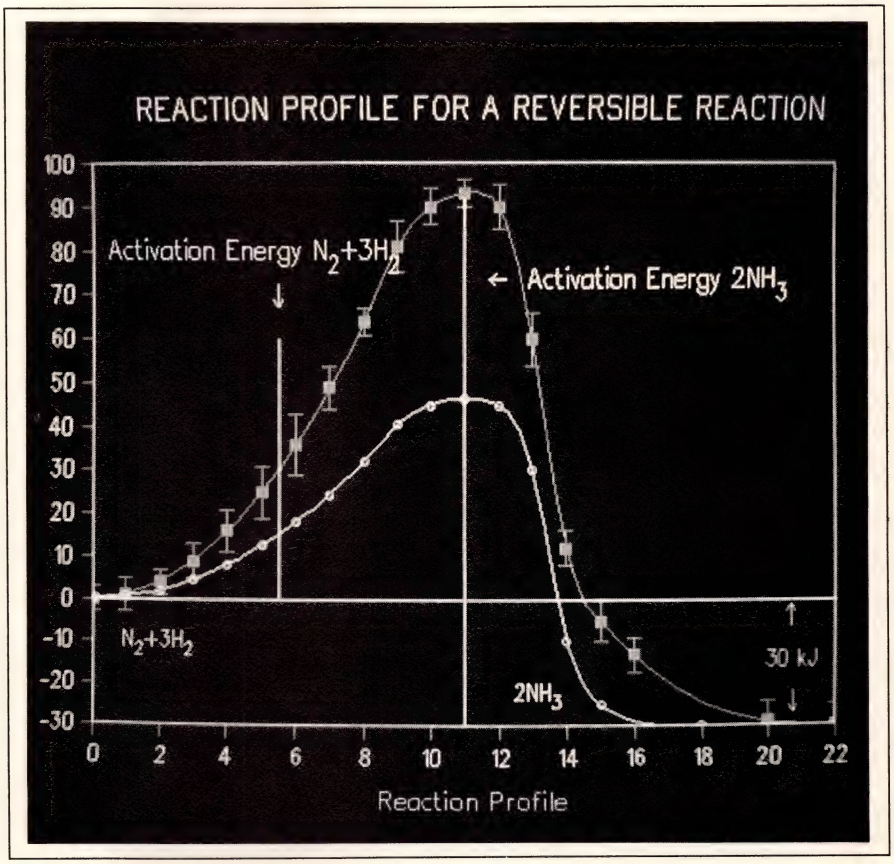
NEW PRODUCTS

CAE & SOFTWARE DEVELOPMENT TOOLS

Plotting-Software Interface

- *Lets you link technical graphing to your own applications*
- *Works with plotters, and laser and dot-matrix printers*

The Auto*TGP tool set includes a macro language for the vendor's Tech*Graph*Pad 4.0 graphing software and lets you graph data from your own engineering software without having to program graphing routines and output-device drivers. Auto*TGP provides your applications (including Lotus 1-2-3, Symphony, Quattro, and other data-analysis programs such as LabTech Notebook) with access to all of the functions of Tech*Graph*Pad. These functions include a variety of plot types, labeling, curve-fitting and data-smoothing, and graph-exporting facilities. The tool set will handle probability and histogram plots, including the ability to calculate the distribution, cumulative probability, and mean and standard deviations from a set of observations,. The interface works directly with PostScript printers or can create a PostScript file for export to desktop-publishing or word-processing software. The software runs on IBM PCs, PS/2s, and compatibles. You'll need at least 640k bytes of RAM, a hard disk, and MS-DOS 2.1 or a later version. Other versions run on Apollo 3000/4000 workstations that have a DOS emulator, and on VAXstations that have VMS services for MS-DOS. Tech*Graph* Pad 4.0, $395; Auto*TGP, $199.



Binary Engineering, 400 Fifth Ave, Waltham, MA 02154. Phone (617) 290-5900. **Circle No. 385**

Grammar And Style Checker For The Macintosh

- *Analyzes grammar and style of a document*
- *Inserts recommendations for improving clarity*

RightWriter for the Mac works with your word processor to help you correct grammatical errors and improve your style. It is not a spelling checker; it analyzes your document, applying more than 4500 rules of good writing, and inserts helpful comments into the text. While reviewing the analyzed version, you can incorporate the suggested changes if you agree with them, or ignore the suggestions. You can adjust the level of analysis to suit your intended audience. You can also initialize the program to turn off or modify various rules that may not suit your type of document. The program indexes readability, use of adverbs and adjectives, and use of jargon; it can print an overall readability report in addition to the suggestions inserted into the text. The program runs on any Macintosh that has at least 512k bytes of RAM and 800k bytes of disk storage; it is compatible with MacWrite, WriteNow, WordPerfect, Microsoft Word, and ASCII documents. A version is also available for IBM PCs and compatibles. $95.

RightSoft Inc, 4545 Samuel St, Sarasota, FL 34233. Phone (813) 923-0233. FAX (813) 921-7849.

Circle No. 386

Development Tool For OSF/Motif User Interfaces

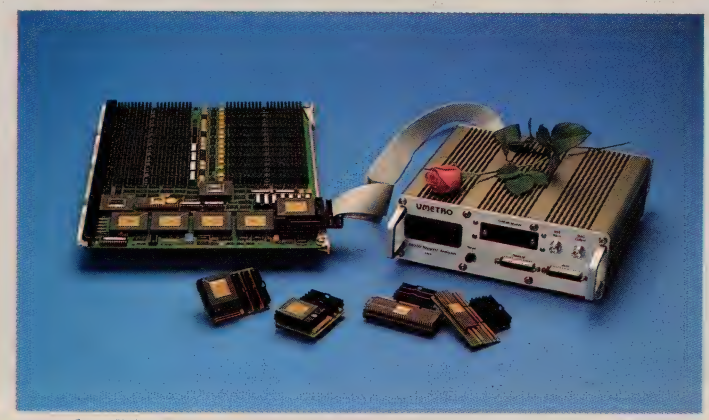
- *Lets you build screens and dialogue boxes*
- *Integrates your screens with runtime library functions*

TeleUse is a software package for interactively developing graphical user interfaces, such as Motif, inde-

pendently of the application code. The package has four components: a graphical layout editor, which lets you combine, edit, and modify predefined screen objects from a library, or create new objects by painting them on the screen; a dialogue language, which lets you specify the actions to be performed when screen events occur; a user-interface builder, which integrates your screen description and dialogue-control specifications with routines from the runtime library to create an executable program; and the runtime library, which contains all of the graphical routines needed. The development package runs on Sun-3, Sun-4, Data General Aviion, and DECstation computers. $9900, including a runtime license for Motif.

TeleSoft, 5959 Cornerstone Ct W, San Diego, CA 92121. Phone (619) 457-2700. FAX (619) 452-1334.
Circle No. 387

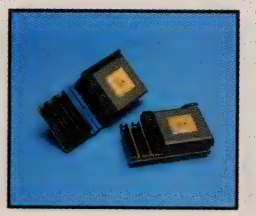
88K RISC & 68K Program Analyzer

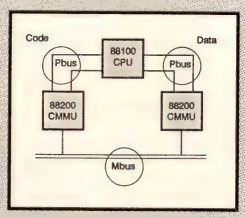


By means of small, low-cost target adapters, the PMA-030 Real-time Program Analyzer can be used for efficient program debugging of the 88100/88200 as well as the 68030, 68020, 68010/00, and 68008.

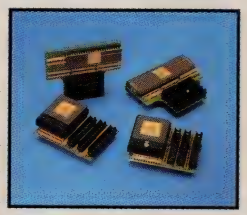
VMETRO's unique PMA-030 Real-time Program Analyzer can now also be used with the 88000 RISC processor. The PMA-030 offers powerful triggering/filtering and a 2K trace memory, displaying a disassembled or decoded trace on an ASCII terminal or PC. Together with unique cache hit ratio and MIPS measurements, this makes the PMA-030 ideal for uP development, testing and performance analysis. The PMA-030 gives unrivaled analysis capability in an ultra-compact, portable instrument.

Two 88000 probes give access to the code and data Pbus and the Mbus.





The 68K family probes support the 68030, 68020, 68010/00 and 68008



VMETRO

The Bus Analyzer Specialist

VMETRO A/S
Sognsveien 75, N-0855 Oslo 8, Norway
Tel: +47 2 39 46 90 Fax: +47 2 18 39 38

VMETRO, Inc.
2500 Wilcrest, #550, Houston, TX 77042
Tel: (713) 266-6430 Fax: (713) 266-6919

Speech-System Development Tool Kit

- *Records speech in digital format and play back in speaker's voice*
- *Can recognize a set of complete sentences as spoken by humans*

The Speech System V Toolkit 2.0 lets you develop a broad range of speech applications for 80386-based computers running Unix or Xenix. The software includes an interface to the vendor's 1500 computer, which allows you to develop your application on the 1500 computer and allows applications running on the 386-based machine to access data stored on the 1500. The software and runtime libraries provide the abilities to read aloud English information stored in an ASCII file, to record a spoken voice in digital format and play it back in the speaker's voice, to answer telephones and place calls, and to recognize complete sentences as they are spoken by humans. A complete development kit costs $2000; a runtime package costs $1000.

Texas Instruments Inc, Information Technology Group, Box 181153, ITG-030, Austin, TX 78718. Phone (800) 527-3500 or your local office. **Circle No. 388**

Logic Circuit Analyzer

- *Lets you define components by Boolean expressions*
- *Provides links to other software tools*

The LCA-1 (Logic Circuit Analysis) version 1.20 software package simulates digital circuits. It provides 4-state logic simulation with tabular and real-time graphical output. This

BUSS



SMD-TRON® FUSES PROTECT YOUR PCB AND WITHSTAND RIGOROUS REFLOW SOLDERING.

Bussmann's new subminiature SMD Tron fuse offers increased fault protection. It is the first fuse to provide for the economies of surface mounting—retaining its high-performance characteristics under the rigors of automated production. ■ Its current-limiting capability has never before been available to electronic designers. When a fault occurs, the SMD Tron fuse holds destructive let-through thermal/magnetic energy to a fraction of its potential. Your PCB components are protected as well as the equipment—a competitive advantage for you. ■ SMD Tron is also fully compatible with the thermal stress of vapor phase, infrared and wave soldering. Its high-temperature, standard JEDEC body survives 10-minute exposure to 218° C, fluorinert vapor, as well as board washing. ■ SMD Tron fuses have proved themselves in multi-national product application trials, for more than a year...both in protecting customers' product circuitry and meeting automated manufacturing requirements. For samples and information, contact your Bussmann distributor or Bussmann directly.

BUSSMANN–LEADER IN CIRCUIT PROTECTION WORLDWIDE

BUSSMANN
P.O. Box 14460
St. Louis, MO 63178
Phone: (314) 394-2877
FAX: (314) 527-1445

BUSSMANN
Cooper (U.K.) Limited
Beswick Works
Frome, Somerset BA111PP
United Kingdom
Phone: +44(0)373-64311
FAX: +44(0)373-73175

BUSSMANN FAR EAST
The Plaza
7500 A Beach Road
No. 14-319/320
Singapore 0719
Republic of Singapore
Phone: +65-298-8311
FAX: +65-296-3807

COOPER INDUSTRIES **BUSSMANN**

CIRCLE NO. 139

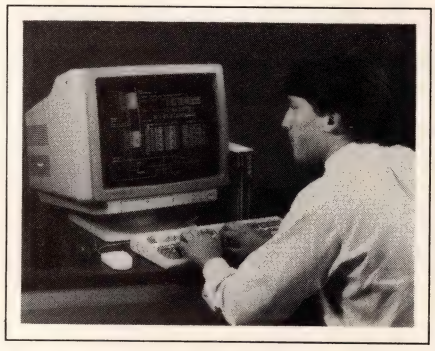
recent release lets you define components by means of Boolean expressions, lets you define the initial state of internal nodes of your circuit, and provides links to other software tools. The Boolean-expression feature accepts input in the form of logic-operator words or symbols. The internal-node-initialization feature eliminates ambiguities and can simulate a hardware configuration. A constant-signal feature lets you define permanently high and permanently low signal lines; when you're working with ASICs that have redundant pins, the program manages high and low lines by means of macros that mimic the in-circuit behavior of those pins. The program records every point within a circuit, together with every event, and lets you spool data to external application programs for comparison with ATE checks running in real time. The program runs on IBM PCs and compatibles that have at least 256k bytes of RAM. $495.

Tatum Labs Inc, 3917 Research Park Dr, B-1, Ann Arbor, MI 48108. Phone (313) 663-8810. FAX (313) 663-3640. **Circle No. 389**

Enhanced PLD-Design Tool

- *Supports Altera erasable PLDs*
- *Automatically selects the user's choice of configurations*

OrCAD/PLD 1.20 is a greatly enhanced version of a tool set for designing programmable devices. The original version (1.10) can handle more than 2400 devices from almost all manufacturers; version 1.20 can additionally handle the very complex Altera devices of the 300, 600, 900, and 1800 families, as well as the 20RA10 and 16RA8. The program extracts PLD-specific information from a schematic generated



by the vendor's schematic-capture tool (OrCAD/SDT III) and generates a JEDEC file for programming the device. Another new feature helps you work with Lattice GALs; the automatic device-configuration feature accepts your choice of configuration (registered, simple, or complex) and modifies the compilation process accordingly, thereby saving you a great deal of preparatory work. The software runs on IBM PCs, PS/2s, and compatibles. $495 for new purchasers; no charge for upgrade from version 1.10.

OrCAD Systems Corp, 3175 NW Aloclek Dr, Hillsboro, OR 97124. Phone (503) 690-9881.

Circle No. 390

Multiuser PC Security System

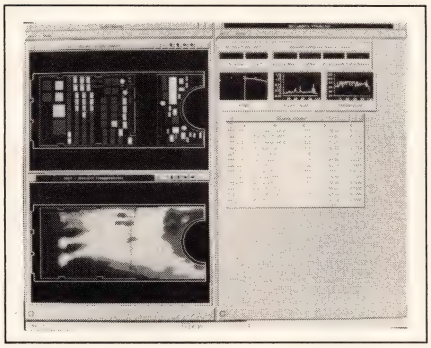
- *Can restrict access to specific directories*
- *Detects any virus and warns users when a program is infected*

The XLock-50 security system for IBM PCs and compatibles can either serve multiple users or run as nodes on a network. The system consists of a half card, which plugs into the PC, and software for virus detection. The Program Authentication Module (PAM) can detect any virus and warns users if a program becomes infected. Further, the PAM monitors all programs and users for each PC and prevents a program from running unless it is on an approved list of programs authenticated by the system administrator; thus, the PAM greatly reduces the likelihood of a virus being



introduced from any source. The Directory Control Module (DCM) allows the system administrator to restrict access to specific directories. The package comes with a physical cylinder lock that prevents unauthorized removal of the XLock card from the PC. The system has been tested with Novell and IBM Token-Ring networks. From $395.

X-Lock, 2001 Westside Pkwy, Suite 190, Alpharetta, GA 30201. Phone (404) 396-6395. FAX (404) 740-8050. **Circle No. 391**



Reliability-Prediction Software

- *Includes MIL-HDBK-217E modeling*
- *Library contains thermal, mechanical, and reliability data*

The Reliability Predictor automates reliability calculations and tracks reliability predictions through a product's design cycle. In addition to the MIL-HDBK-217E modeling method, you can use any other reliability-calculation methods. The package consists of the AutoTherm tool for thermal analysis of your design; the SmartParts library, which features more than 4500 analog and digital parts and includes a supplement of thermal, mechanical, and reliability data for each part; and the Decision Support System, which is a spreadsheet tool for gathering, calculating, and displaying reliability data. Using basic schematic data and some assumptions regarding packaging and temperature, the package can identify design areas that will affect reliability and then monitor them throughout the design cycle. $10,000.

Mentor Graphics, 8500 SW Creekside Pl, Beaverton, OR 97005. Phone (503) 626-7000. **Circle No. 392**

Simulator And Analyzer For PC-Board Design

- *Simulates transmission-line effects*
- *Analyzes circuits for ringing, crosstalk, and time delays*

Greenfield is a family of CAE tools for the analog simulation and analysis of high-speed digital systems. You can simulate printed-circuit boards, hybrid and integrated circuits, cables, connectors, and other interconnection components. Greenfield2d is a geometric modeler that accepts cross-sectional information on board traces, connector pins, and cables, and applies the boundary-element method to solve high-speed transmission-line problems. The program can model complicated systems of cables and connectors. A related tool called E.Z.Greenfield3d can produce detailed 3-D models that include vias, corners, crossovers, and steps. Phyllis (Physical Load and Line Simulator) can use the parameters calculated by Greenfield2d to analyze circuits for ringing, crosstalk, and time delays in the time domain. The tool set runs interactively or in batch mode on Apollo, Sun, Cray, Hewlett-Packard, Intergraph, and other computers. From $30,000 for workstation versions.

Quantic Laboratories Inc, 281 McDermot Ave, Suite 200, Winnipeg, Manitoba, Canada R3B 0S9. Phone (204) 943-2552; in US, (408) 286-5576. FAX (204) 957-1158. **Circle No. 393**



CONTROLLI

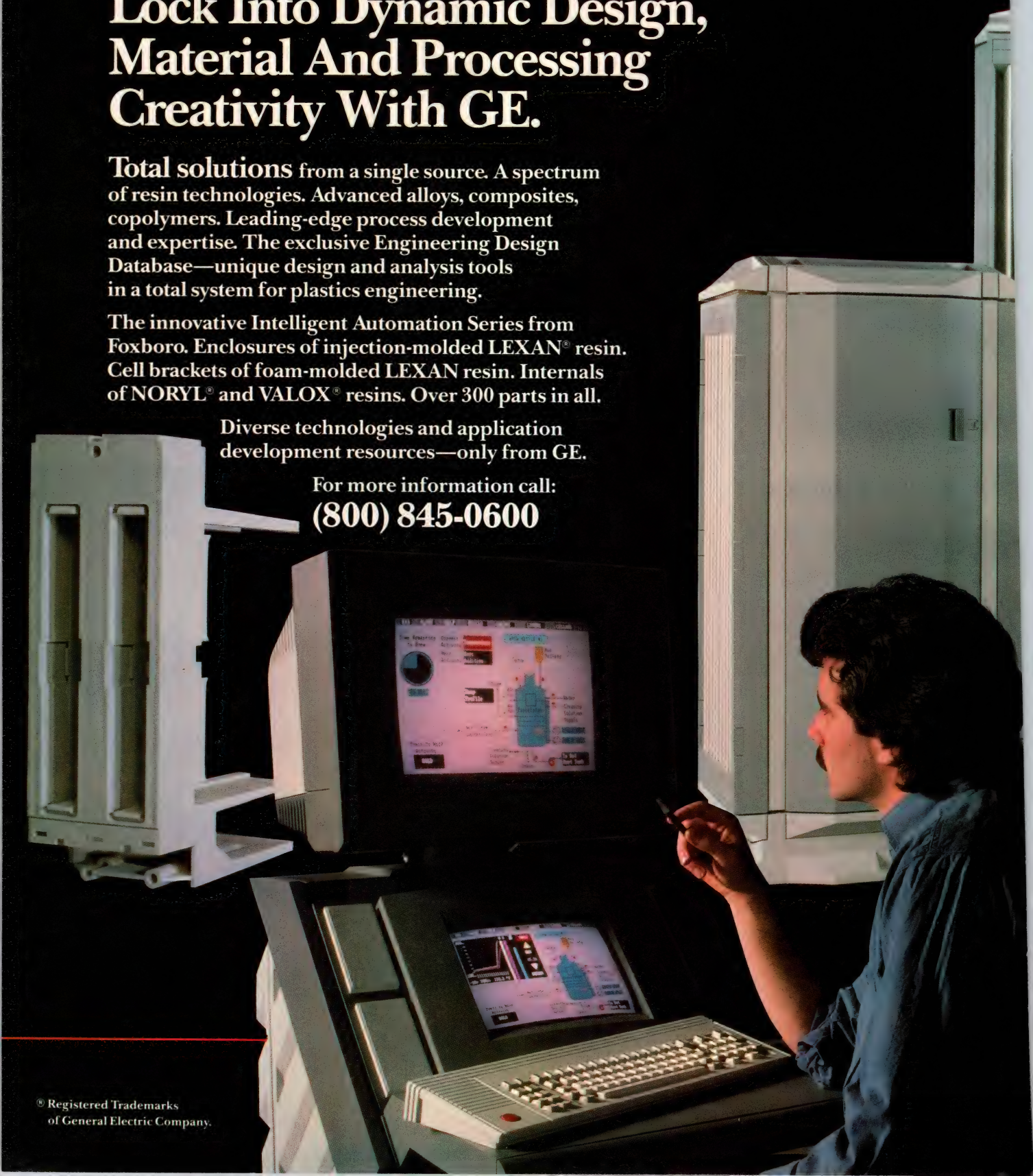
Lock Into Dynamic Design, Material And Processing Creativity With GE.

Total solutions from a single source. A spectrum of resin technologies. Advanced alloys, composites, copolymers. Leading-edge process development and expertise. The exclusive Engineering Design Database—unique design and analysis tools in a total system for plastics engineering.

The innovative Intelligent Automation Series from Foxboro. Enclosures of injection-molded LEXAN® resin. Cell brackets of foam-molded LEXAN resin. Internals of NORYL® and VALOX® resins. Over 300 parts in all.

Diverse technologies and application development resources—only from GE.

For more information call:
(800) 845-0600

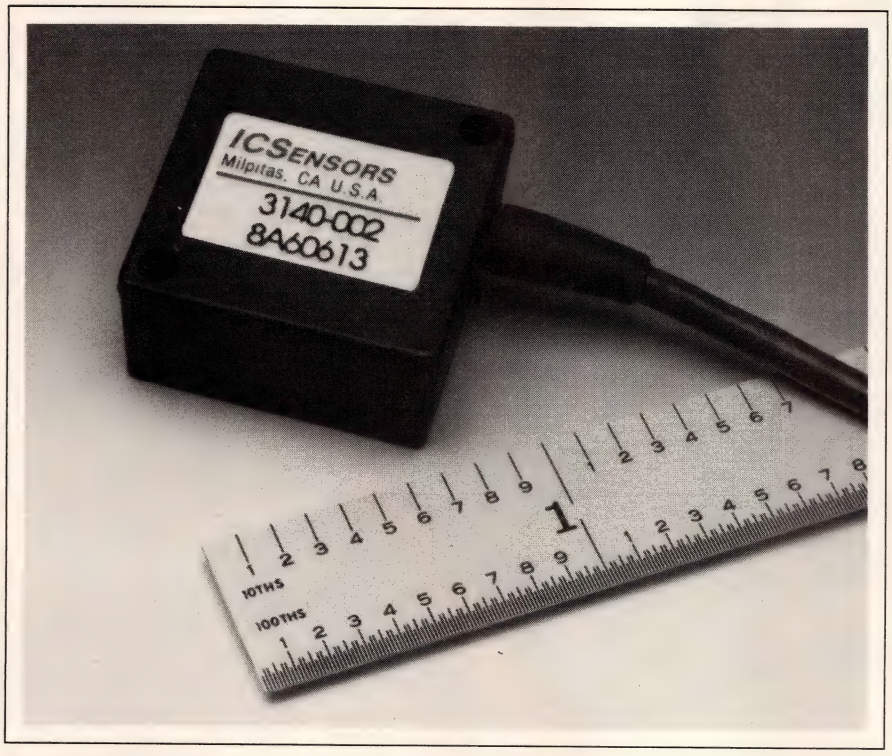


® Registered Trademarks of General Electric Company.


G CHANGE
GE Plastics
CIRCLE NO. 140

NEW PRODUCTS

COMPONENTS & POWER SUPPLIES

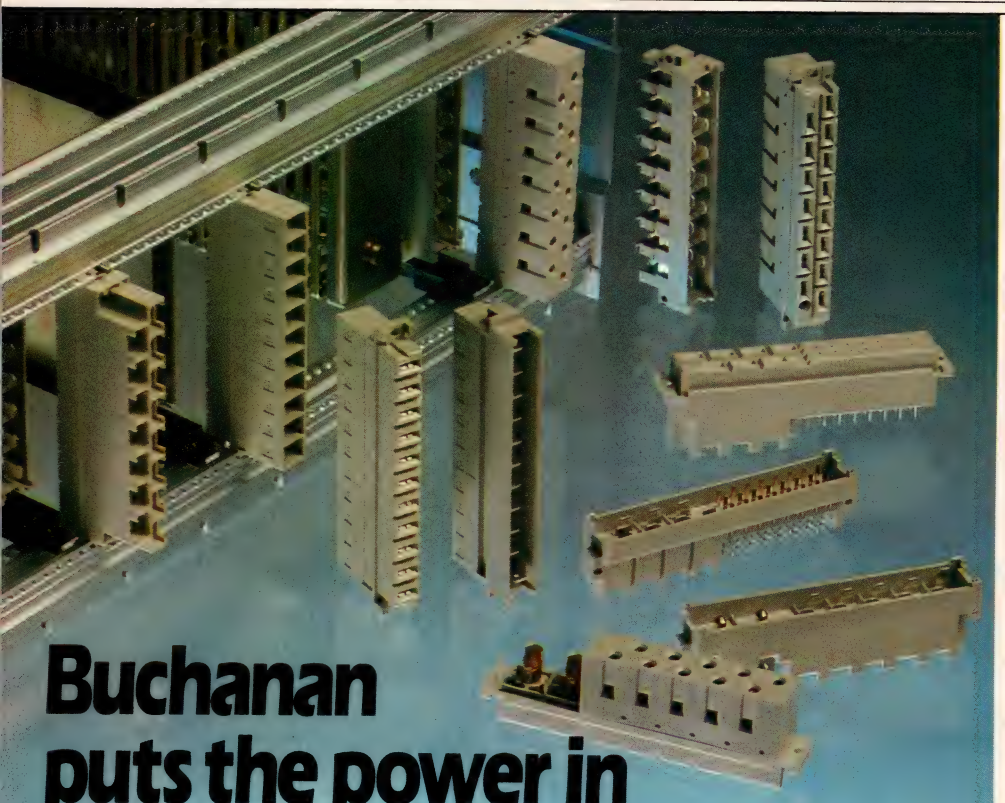


Silicon Accelerometer

- *Measures to ±100g*
- *Includes signal conditioning*

Model 3140 is a silicon-based accelerometer that offers full-scale measurement ranges of ±2 to ±100gDevice output is compensated to eliminate errors due to temperature. Full-scale output equals ±2V about a 2.5V offset level. A built-in regulator provides the offset-voltage reference and also allows the device to operate from an unregulated power supply. The 3140 also features built-in signal-conditioning circuitry. Operating range spans −20 to +85°C. The unit is housed in a plastic package, which includes a shielded cable for electrical terminations. $150 (1000).

IC Sensors, 1701 McCarthy Blvd, Milpitas, CA 95035. Phone (408) 432-1800. **Circle No. 351**



Buchanan puts the power in DIN 41612 connectors.

CIRCLE NO. 141

Newest members of the growing family of Buchanan electronic connectors. Until now, DIN 41612 connectors have been limited to low amperage signal applications. NOW, NEW BUCHANAN-2E POWER DIN CONNECTORS PROVIDE HIGH AMPERAGE POWER CONTACTS, making these connectors the ideal interface in a wide variety of situations — especially in power-supply-to-motherboard applications.

Buchanan-2E power DIN connectors give you:

- A versatile series of 2-piece DIN 41612 connectors with power or power *and* signal contacts in one connector.
- Variety of high amperage models with 15A or 20A ratings — plus the option of adding two 50A contacts.
- Full compatibility with DIN/Eurocard standard or other 19" rack systems.
- Wide variety of terminal styles: Quick-connect, PC, extended PC, wire wrap, screw, or hand solder.

Send for Catalog I/O 300A to select a sample that fits your application.

amerace INDUSTRIAL ELECTRICAL PRODUCTS

AMERACE CORPORATION
INDUSTRIAL ELECTRICAL PRODUCTS
530 W. MT. PLEASANT AVENUE
LIVINGSTON, NJ 07039 ■ (201) 992-8400
TELEX: 13-8403 ■ FAX: 201-992-9416

BUCHANAN®

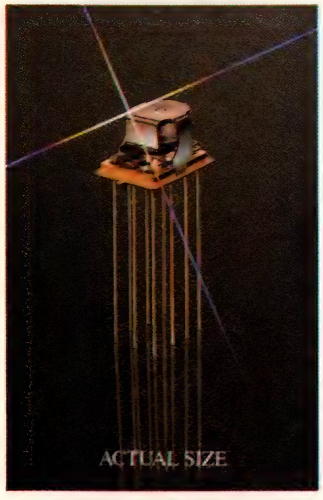
2E

408

TO-5 RELAY TECHNOLOGY

The CMOS Compatible Centigrids®

- Driven directly from CMOS logic
- No amplification or buffering needed
- Fewer components/connections = greater reliability
- Both latching & non-latching versions available



That's right. These little relays are truly CMOS compatible. You can drive them directly with CMOS level signals. No outside amplification at all. An integral power FET driver gives you all the amplification you need. A large Zener diode protects the FET gate input. And all this plus a DPDT relay and coil suppression diode are packed into a tiny Centigrid can.

You can see the advantages up front. Fewer components and connections mean increased reliability. Simpler board layout, too. Add to that the rugged construction and proven contact reliability that have made Centigrid a byword in the industry, and you have a sure winner. One that's QPL approved to MIL-R-28776/7 and 8. One thing more. One version of this little beauty is also a Maglatch. A short pulse of power sets the relay, and it stays that way until it is reset.

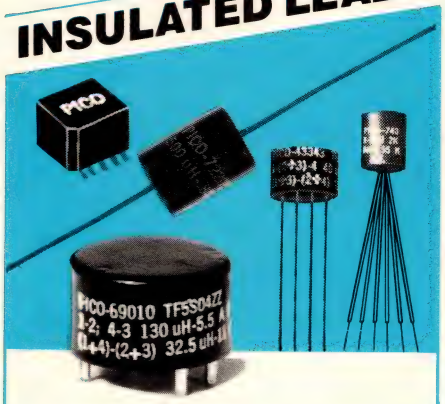
No holding power is required. That makes it ideal for applications where power is at a premium. The versatile CMOS compatible Centigrid. It is available in general purpose (116C) sensitive (136C) and Maglatch (122C). Call or write for complete information.

TELEDYNE RELAYS
Innovations In Switching Technology

Teledyne Relays, 12525 Daphne Ave., Hawthorne, California 90250 • (213) 777-0077/**European Headquarters**: W. Germany: Abraham Lincoln Strasse 38-42, 6200 Wiesbaden/Belgium: 181 Chaussee de la Hulpe, 1170 Brussels/U.K.: The Harlequin Centre, Southall Lane, Southall, Middlesex, UB2 5NH/ Japan: Taikoh No. 3 Building, 2-10-7 Shibuya, Shibuya-Ku, Tokyo 150/France: 85-87 Rue Anatole-France, 92300 Levallois-Perret.

PICO POWER
INDUCTORS

PLUG-IN
SURFACE MOUNT
AXIAL INDUCTORS
TOROIDAL
INSULATED LEADS



PICO's Ultra-Miniature Power Inductors are ideal for Noise, Spike and Power Filtering Applications in Power Supplies, DC-DC Converters and Switching Regulators.

- QPL standards available MIL-T-27/356
- Temperature range −55°C to +130°C
- All units are magnetically shielded
- All units meet the requirements of MIL-T-27 (TF5S04ZZ)
- Minimum possible size
- Split windings
- Inductance values to 20mH with DC currents to 23 amps

PICO manufactures complete lines of Transformers, Inductors, DC-DC Converters and AC-DC Power Supplies

Delivery—stock to one week

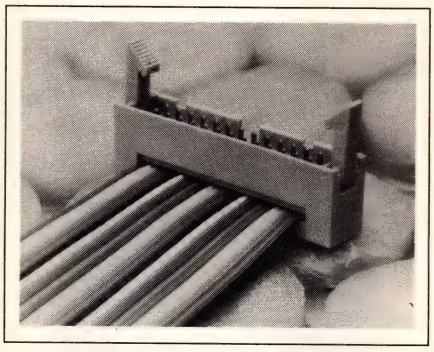
SEE EEM, THOMAS REGISTER OR SEND DIRECT FOR FREE PICO CATALOG

PICO Electronics, Inc.
453 N. MacQuesten Pkwy. Mt. Vernon, N.Y. 10552
Call Toll Free 800-431-1064
IN NEW YORK CALL 914-699-5514

Planar Cable Headers

- *Offer as many as 60 positions*
- *Have a 94V-0 UL rating*

IDC headers are designed to terminate 0.05-in. planar cable. They feature 1-step termination and mate with standard IDCs. You can order any of the 10- to 60-position headers with or without mounting flanges and with the choice of no latches, short latches, or long latches for



mating sockets with strain relief. Contact material is phosphor bronze with gold plating over tin. Insulation material has a 94V-0 UL flammability rating. The contacts are rated for 1A and have a proof voltage of 1000V dc. $2.20 for a 26-position model.

Carrot Components Corp, 4620 Calle Quetzal, Camarillo, CA 93012. Phone (805) 484-0540. FAX (805) 484-7458. **Circle No. 352**

Power Transformers

- *Operate anywhere in the world*
- *Feature separate primary and secondary windings*

The International Series of power transformers includes versions with 5, 10, and 20 VA ratings. All units carry a wide range of approvals from UL, IEC, and VDE, making the units compatible with applications just about anywhere in the world. Each transformer features anchor, insulating, and crossover tapes as well as shrouded primaries. The units are not bifilar wound—instead they have separate windings for each primary and each secondary. The devices are totally immersed in epoxy, so they will withstand aqueous and solvent cleaning systems. The units undergo a 4500V rms dielectric strength test. From $2.93 (OEM qty).

Prem Magnetics Inc, 3521 N Chapel Hill Rd, McHenry, IL 60050. Phone (815) 385-2700. FAX (815) 385-8578. **Circle No. 353**

Memory Module Sockets

- *Have a 94V-0 UL rating*
- *Provide 80 positions*

Metal-latched Micro-Edge sockets eliminate the breakage associated with improper single in-line memory module (SIMM) insertion/extraction and inconsistent SIMM board manufacturing. The units have phosphor bronze contacts with plating of either tin/lead or gold plate over nickel. Socket housings are constructed of 94V-0 UL-rated liquid crystal polymer, and the latches are made of brass with nickel plate. The units are available with 0.05- and 0.1-in. contact spacings in vertical and low-profile/angled versions. Single- and tandem-row 0.1-in. devices are available with 22 to 42 positions; single-row 0.05-in. units are available with 40 to 80 positions. $2.40 (1000). Delivery, six to eight weeks ARO.

AMP Inc, Box 3608, Harrisburg, PA 17105. Phone (800) 522-6752. **Circle No. 354**

Modular Terminal Blocks

- *Carry a 94V-0 UL rating*
- *Available in 2- and 3-pole versions*

Series 8191 modular terminal blocks interlock to let users form a continuous terminal strip with any number of poles. The units are available in 2- and 3-pole versions. Features include a pressure-clamp termination scheme, a 94V-0 UL-rated housing, and built-in test points at each pole. Rated for 15A at 250V or 10A at 300V, the blocks meet UL, CSA, and VDE standards. Blocks are

"EDN MAGAZINE'S PRODUCT MART SECTION IS HELPING US BECOME A LEADER IN OUR MARKETPLACE."

Raymond J. Schnorr
Vice President of Marketing
ACCEL Technologies

As Vice President of Marketing, Ray Schnorr is responsible for marketing ACCEL Technologies' affordable, professional software that meets the design needs of electrical engineers. He operates on a fixed budget and demands results. "When it comes to buying media, I'm interested in two things: performance and price. With EDN's Product Mart section, I pull high-volume sales leads and meet my budget," says Schnorr.

In nineteen months, ACCEL has sold 5000 software packages to 3000 sites. "Our ⅓-page Product Mart ads in EDN magazine are allowing us to reach our target audience." And Schnorr sees more for EDN and ACCEL. "We have significant growth plans for ACCEL, and running bigger ads in EDN will be part of the strategy to get there.

"The power and prestige of EDN is helping us grow into a leading design software company."



EDN magazine works for ACCEL Technologies. It can work for you.

EDN

Where Advertising Works

available with 5- or 5.08-mm pole spacings and with either open or closed bases. Solder pins are hot tinned bronze, and the pressure clamps are nickel-plated brass. $0.41 (100) for a 2-pole model.

Wieland Inc, 466 Main St, New Rochelle, NY 10801. Phone (914) 633-0222. **Circle No. 355**

Crystal Oscillators

- *Compatible with CMOS and TTL*
- *Operate at 0 to 70°C*

H10BV and T10BA temperature-compensated crystal oscillators are compatible with CMOS and TTL, respectively. Both lines cover an 80-kHz to 32-MHz range. Standard frequency stability over a 0 to 70°C range equals ±5 ppm. The oscillators operate from a 5V supply and draw a maximum of 25 mA. Using a 0.5 to 4.5V dc control voltage, you can adjust oscillator output frequency ±10 ppm min. The oscillators are housed in 14-pin DIPs. $53 (10). Delivery, stock to six weeks ARO.

Conner-Winfield Corp, 1865 Selmarten Rd, Aurora, IL 60505. Phone (708) 851-4722. FAX (708) 851-5040. **Circle No. 356**

Burn-In Sockets

- *Handle 125°C*
- *Accept pin-grid-array devices*

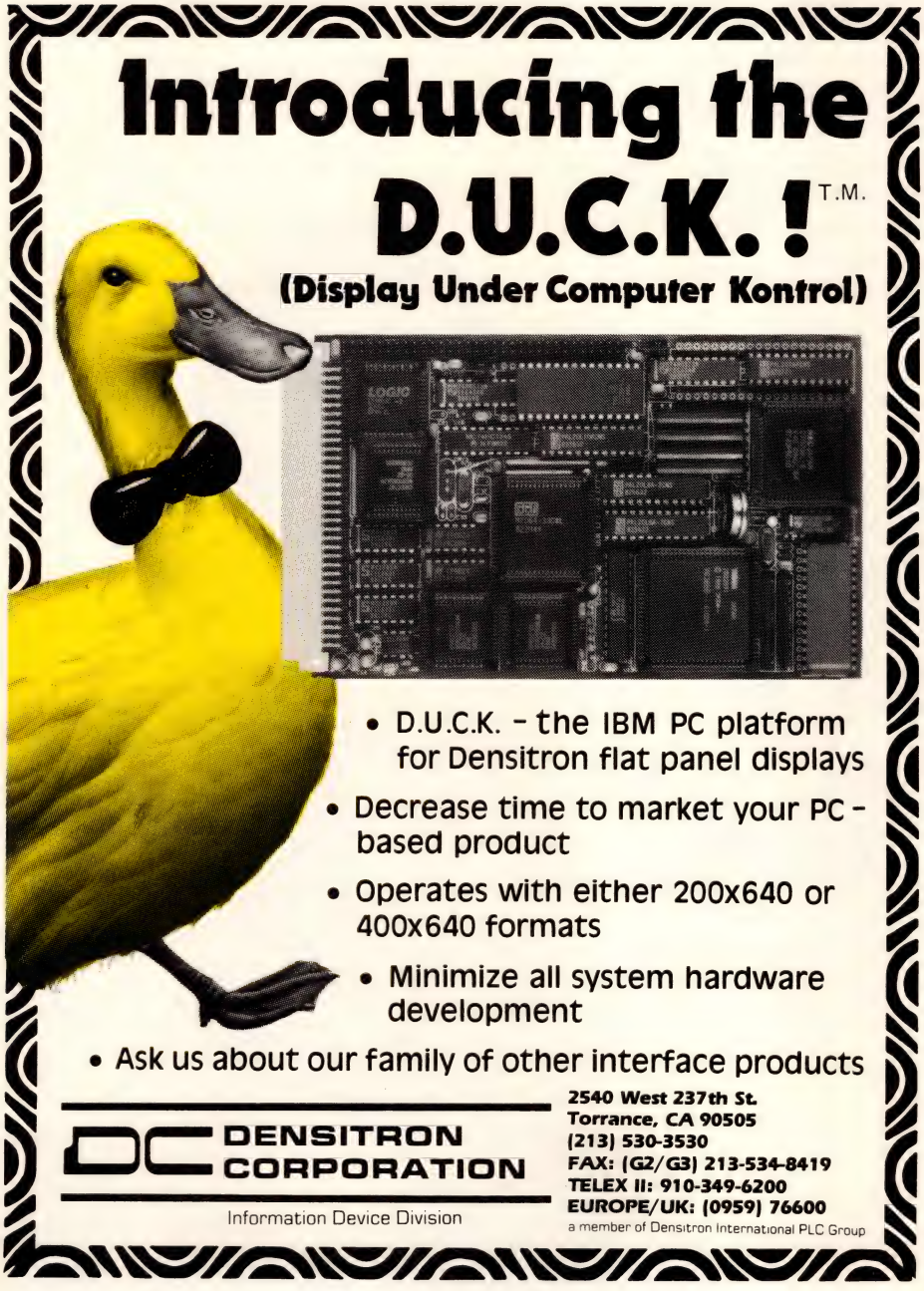
Designed for both test and burn-in service, these zero-insertion-force, pin-grid-array sockets are available with either gold-plated beryllium copper or nickel boron-plated alloy contacts. Operating ranges for the two types of contacts measure −65 to +125 and −65 to +200°C, respectively. Socket bodies are molded of heat-resistant PPS material. The contacts are normally closed. A stainless-steel cam lever provides smooth, positive action. The sockets are available in grid sizes ranging from 12×12 through 21×21. $42.50 to $70 for a fully loaded 15×15 model.

Aries Electronics Inc, Box 130, Frenchtown, NJ 08825. Phone (201) 996-6841. FAX (201) 996-3891. **Circle No. 357**

Linear Power Supplies

- *Designed for common market applications*
- *Offer a single output*

The CMI Series of external, linear power supplies are designed for the European market. All five models are TUV approved and accept inputs of 200 to 250V ac, 50 Hz—values typically found throughout continental Europe, the United Kingdom, and Australia. Input connections are made via a VDE-approved IEC connector. The series of two



CIRCLE NO. 145

HANSEN'S REMARKABLE RELIABILITY

Reliability. It's worth considering. Especially, when you are selecting a motor and a motor manufacturer.

You know Hansen for their superior motors—the motors with reliability built in from design to assembly. Such motors as Synchron®, D.C. Servo, and Stepper always fulfill your highest expectations. Hansen is the one company you can count on for excellent quality, service and delivery.

It's time you discovered how remarkable it is to be 100% sure. Rely on Hansen.

Hansen
The Mark of Reliability



Hansen Manufacturing Company, Inc. ● P.O. Box 23, Princeton, Indiana 47670 ● Phone: 812-385-3415 ● FAX: 812-385-3013
a subsidiary of IMC MAGNETICS CORP.

MAXIMUM PERFORMANCE WITH MINIMAL HEAT



- IERC military packaging products include ZIF circuit board retainers, custom coldwalls and enclosures and SEM card cages.
- Superior thermal conductivity increases reliability and provides higher density packaging of electronics
- Unique ¼ turn positive LOCK/UNLOCK simplifies board replacement and meets MIL-STD-810C for vibration and shock
- When the action's hot . . . IERC comes to the rescue!

IERC
International Electronic Research Corporation
a subsidiary of Dynamics Corporation of America
135 W. Magnolia Blvd., Burbank, CA 91502
(213) 849-2481 • (818) 842-7277 • FAX: (818) 848-8872

CIRCLE NO. 147



Galileo had to invent the most technologically advanced test equipment of his time. You can rent.

Galileo had to devise the telescopes that proved the Earth revolves around the Sun. Today, finding the best test equipment is simple. Rent from Leasametric. Meticulously inspected, tested and calibrated. Flexible, competitive terms. Overnight delivery.

U.S.: 800-553-2255 • Canada: 800-268-6923

Leasametric, Inc.
Electronic Equipment-Renting, Leasing, Sales and Service
A member of The Marmon Group of companies

CIRCLE NO. 148

single-output models (5 or 12V) and three triple-output versions (5 and ±12). All outputs are regulated, and output power levels range from 7.5 to 14W. Output connectors are typically 5-pin DIN types. $25 to $35 (100). Delivery, stock to eight weeks ARO.

Elpac Power Systems, 3131 S Standard Ave, Santa Ana, CA 92705. Phone (714) 979-4440. FAX (714) 241-7293. **Circle No. 358**

PC-Board Relay

- *Rated for 15A*
- *Contact resistance equals 0.1Ω max*

Measuring only $0.85 \times 0.98 \times 0.68$ in., Series 34 general-purpose electromechanical relays are designed for high-density pc-board applications. The relays are available in spst NO and spdt versions. Contacts are rated for 15A at 120V ac resistive. Maximum contact resistance measures 0.1Ω. The relays will operate with inputs of 3 to 48V dc and will trigger with values as low as 180 mW. $1.25 (1000). Delivery, stock to eight weeks ARO.

Airpax, Husky Park, Frederick, MD 21701. Phone (301) 663-5141. FAX (301) 698-0624.

Circle No. 359



DC/DC Converters

- *Have 90% efficiency*
- *Case is totally shielded*

The DC700 Series of dc/dc converters includes six models that provide single outputs of 5, 12, or 15V at

current levels of 3 to 5A. Converter input levels range from 8 to 40V and 18 to 40V, depending on the model. All units are packaged in 3×2.5×0.81-in. cases, which feature six-sided, shielded construction. Line and load regulation measures 0.5%, and noise equals <2%. Efficiency values range to 90%. The converters are designed for pc-board mounting and operate over a −25 to +70°C range. Remote-sense and remote-control features are standard on the 5A models. $89.

Intronics, 150 Dan Rd, Canton, MA 02021. Phone (617) 828-4992. FAX (617) 828-5050.

Circle No. 360

PC-Board Receptacles

- *Offer 70 contacts*
- *Carry a 94V-0 UL rating*

When mated with appropriate headers, A010 and A015 Series pc-board receptacles provide an electrical interface for vertical or stacked board-to-board interconnections. The devices feature protected, tapered, top entry for easy alignment and insertion. The receptacles will accept 0.025-in. square posts or round pins. The units are available in sizes of two to 70 contact positions. The housings are constructed of flame-retardant 94V-0 UL-rated thermoplastic. Integral standoffs ease soldering and cleaning. Gold and tin-lead platings are available. $0.025/pin. Delivery, stock to five weeks ARO.

Augat Interconnection Products Group, 33 Perry Ave, Attleboro, MA 02703. Phone (508) 222-2202. FAX (508) 222-0693.

Circle No. 361

Telephone Line Interface

- *Operates with any modem chip set*
- *Provides 4-kV isolation*

The CH1830 telephone line interface network is designed to meet worst-case International PTT requirements. It has a 4-kV isolation rating and is able to be registered for FCC Part 68. Features include ringing detection, hook-switch control, and provisions for dial-pulse masking. In addition to handling requirements of V.22 (2400 bps and below), the interface will also operate at speeds above 9600 bps to meet standards V.32, V.33, and V.29. The circuit will work with any modem chip set. $50 (1000).

Cermetek Microelectronics Inc, 1308 Borregas Ave, Sunnyvale, CA 94089. Phone (408) 752-5000. FAX (408) 752-5004. **Circle No. 362**



PRESENTING CAHNERS CAPS™. AN ALL-NEW, PRODUCTIVITY-BOOSTING ENGINEERING TOOL THAT AUTOMATES, ACCELERATES, AND OPTIMIZES THE SELECTION OF INTEGRATED CIRCUITS AND SEMICONDUCTORS.

Imagine having up-to-date information on more than 500,000 devices from over 425 manufacturers worldwide at your fingertips.

Think about instantly accessing crisp, clear, unabridged images of manufacturers' datasheets, with the same text, tables, and graphics found in the printed versions.

Consider applying the power of menu-driven parametric searches that can identify ICs which conform to your specifications.

This is CAPS. It's new. It's different. And it gives you the information you need to make critical component selection decisions.

Available on a subscription basis so it's always up to date, CAPS comes complete with all the hardware and software you need to install CAPS on your personal computer or Sun® workstation.

Learn more about how CAPS can take the drudgery out of your component selection process. Call or write:

CAHNERS
CAPS
Computer Aided Product Selection

Cahners Technical Information Service
275 Washington Street
Newton, Massachusetts 02158-1630
Telephone: 617-558-4960
Facsimile: 617-969-6949
Telex: 940573
Toll-free: 1-800-245-6696

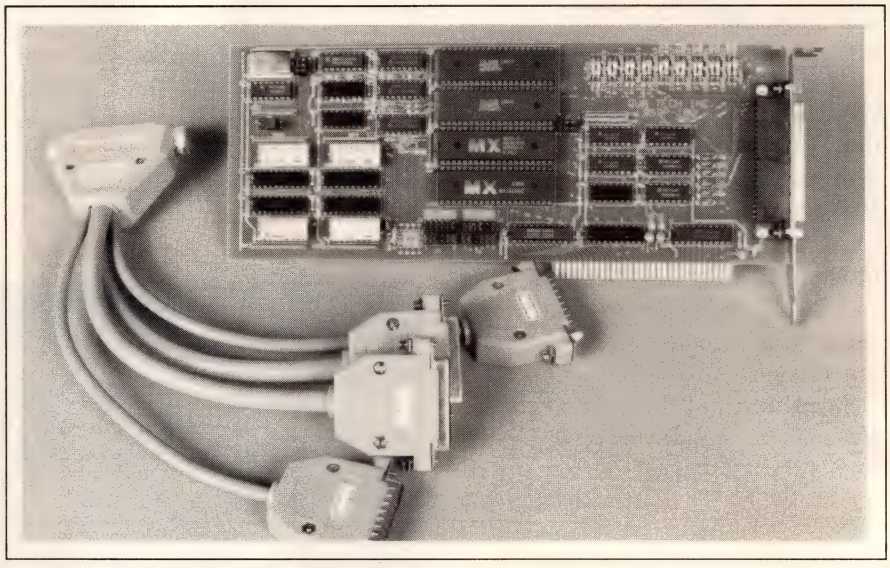
Now available on the Sun-3™ family of workstations

CAPS is a trademark of Reed Publishing, USA.
Sun is a registered trademark and Sun-3 is a trademark of Sun Microsystems, Inc.

CIRCLE NO. 149

Dual Serial/Parallel Board

- *Communications adapter for PC/ATs and compatibles*
- *Has multiple channels*

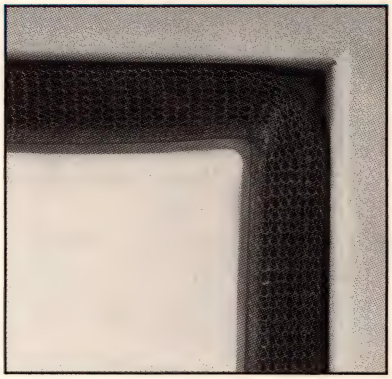


The DSDP-100 communications adapter provides an IBM PC/AT or compatible computer with two additional serial ports and two Centronics-compatible parallel ports. You can use it to interface network file servers with multiple printers, plotters, and other serial and parallel devices, and it occupies only one expansion slot. Each serial port uses a 16450 UART, which supports rates as high as 56k baud. Optional 16550 UARTs for 256k-baud rates are also available. Each parallel port allows bidirectional data transfer, which allows data input through the printer interface. The DSDP-100 comes with a high-density 62-D connector and an adapter cable terminating in two D-25 standard parallel ports and two D-25 standard serial port connectors. $195.

Qua Tech Inc, 478 E Exchange St, Akron, OH 44304. Phone (216) 434-1409. FAX (216) 434-1409. TWX 510-101-2726. **Circle No. 363**

SAVE MONEY WITHOUT CUTTING CORNERS

with SOFT-SHIELD™* EMI Shielding Gaskets



This unique and inexpensive combination of wire mesh over urethane foam offers...

...EXCELLENT SHIELDING AND LOW CLOSURE FORCES. In fact, surpasses FCC shielding requirements for commercial electronics.

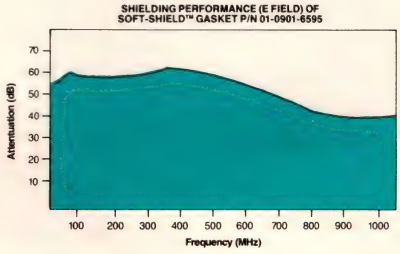
...QUICK AND SIMPLE INSTALLATION. Easily applied with an integral pressure sensitive adhesive strip.

...LOW COST PER FOOT. Costs less than a similar performing conductive cloth over foam gasket.

...COST SAVINGS IN RIGID ENCLOSURE DESIGN. SOFT-SHIELD gaskets fill gaps from 10 to 300 mils in loosely toleranced electronic enclosures and retrofit any design.

Call Toll Free

617-935-4850/800-225-1936



© Chomerics, Inc. 1990 *Patent Pending

FREE SAMPLES AVAILABLE

Clip this coupon to your business card and mail to:

CHOMERICS a GRACE company

Chomerics, Inc.
77 Dragon Court
Woburn, MA 01888-4014

Why 90% of the Top Electronics Companies Use CAPS

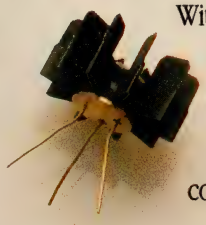
for IC and Semiconductor Search and Selection



CAPS Saves Time and Money

The CAPS™ IC and Semiconductor Search and Selection System boosts your productivity and pays for itself by saving you hours of drudgery and frustration. Engineers and designers who use CAPS consistently report productivity gains between 5:1 and 10:1 over manual methods!

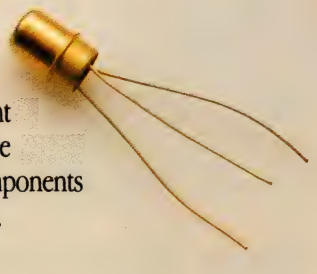
CAPS Keeps Pace with Technology

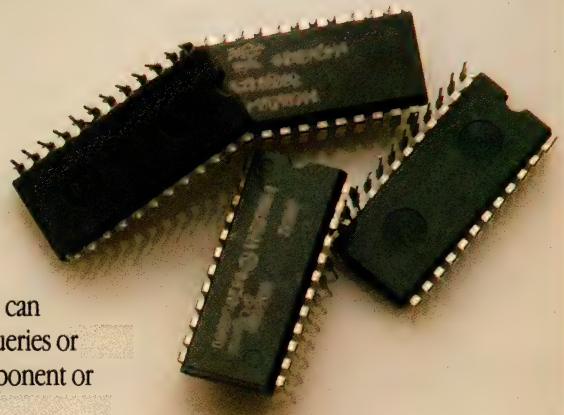


With CAPS, you get updates every month, including new component information, datasheets, and revisions to existing information. CAPS also keeps track of obsolete components for you.

CAPS Finds Facts Fast

CAPS' CD-ROM database gives you instant access to complete technical data on more than 470,000 IC and semiconductor components from over 425 manufacturers worldwide.





CAPS Gives You Control

CAPS puts you in charge. In seconds, you can search the database using either simple queries or special criteria to pinpoint a specific component or compare several candidates.



CAPS Runs on Existing Equipment

When you subscribe to CAPS, you get all the hardware and software you need to add CAPS to your IBM® PC/AT™, 100%-compatible personal computer, or Sun® workstation. So you can get started right away!



Find out why so many of the top companies ranked by *Electronic Business* magazine have made CAPS their IC and semiconductor search and selection tool.

CAPS Delivers the Big Picture

CAPS includes hundreds of thousands of digitally-stored images of manufacturers' datasheet pages, complete with unabridged text and graphics. CAPS even provides cost information and tells you how to contact manufacturers.

For complete information about CAPS, call or write today!

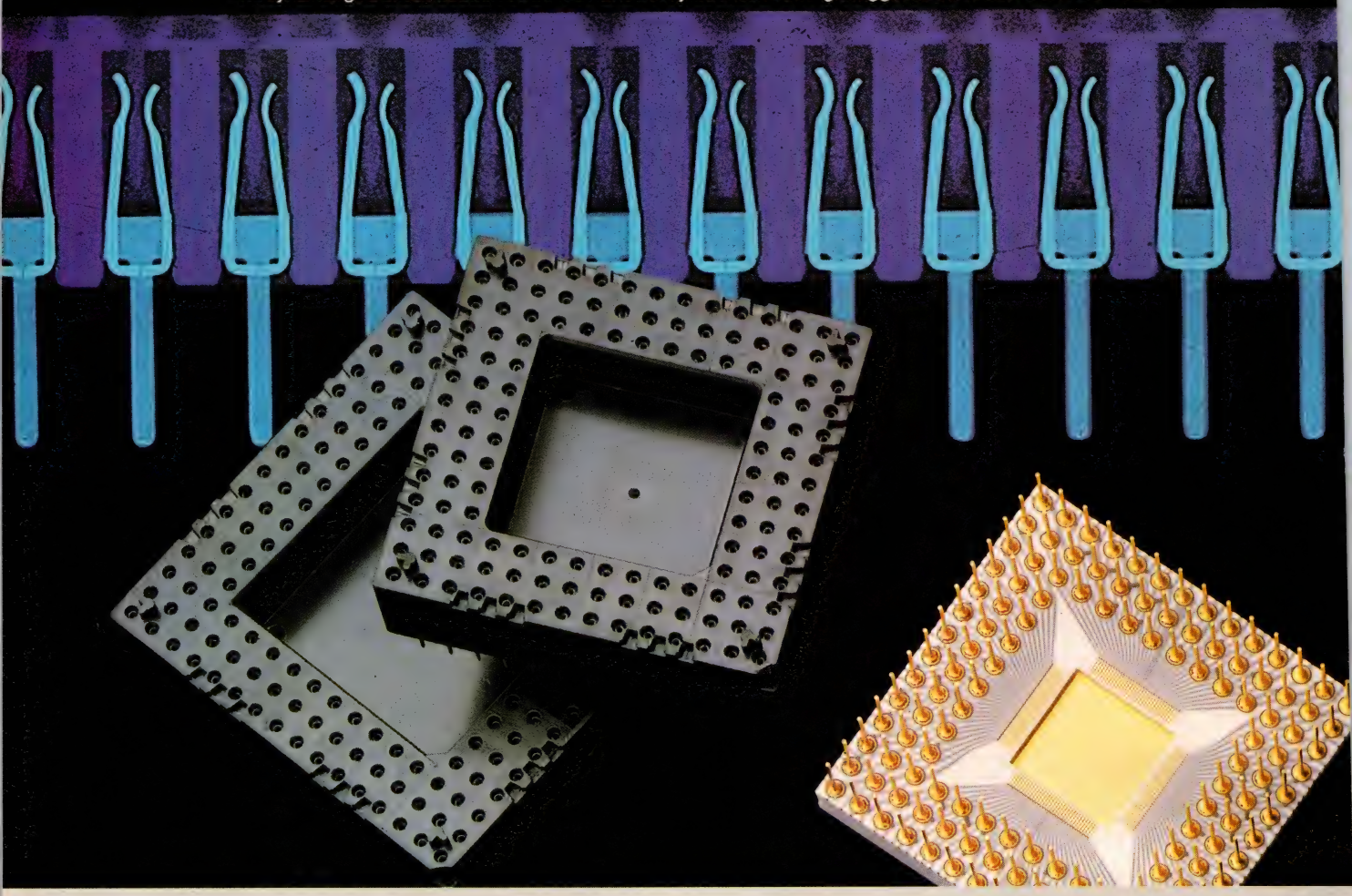
CAHNERS
CAPS
Computer Aided
Product Selection

Cahners Technical Information Service
275 Washington Street
Newton, Massachusetts 02158-1630
Telephone: 617-558-4960
Facsimile: 617-969-6949
Toll-free: 800-245-6696

CAPS is a trademark of Reed Publishing (U.S.A.) Inc.
IBM is a registered trademark and AT is a trademark of International Business Machines Corporation.
Sun is a registered trademark of Sun Microsystems, Inc.

CIRCLE NO. 151

X-ray: Enlarged cross section of LIF Pin Grid Array socket showing staggered cantilever beam contacts.



A revealing look at the difference in high performance IC interconnect systems.

The X-ray of our LIF Pin Grid Array socket is our way of emphasizing that it's what's **inside** an IC interconnect that makes the difference — in performance, reliability, and protection for your valuable IC devices.

To help you make the best choice in IC interconnects, we offer a close look at our new LIF Pin Grid Array socket — it's typical of the engineering quality that we build into our IC interconnect systems.

Unique cantilever beam contacts

- Low insertion (1.7 oz. avg.) and low withdrawal (1.3 oz. avg.) forces, plus high normal force (64 grams/min.) provide for easier insertion/extraction, and maximum performance.
- Our unique, easy-to-use extraction tool lifts the IC device evenly to prevent bent pins and device damage.

Improved design for manufacturability/reliability

- Anti-wicking contact design keeps solder where it belongs — on the solder joint.
- Top-side standoffs prevent contact damage due to over-insertion.
- Our LIF PGA socket is low profile, oriented for robotic placement, and available in standard or custom pin configurations in grid sizes from 10 x 10 through 16 x 16.

The company behind the product

A close look at our company will reveal our strong financial position, our commitment to the future, and our ability to support you worldwide. Write for our Annual Report — it's like an X-ray of our company.

To take a close look at our new LIF Pin Grid Array socket and our versatile line of ANSLEY® High Performance IC Interconnection Systems, and for the location of our nearest stocking distributor, call

1-800-344-4744.

Thomas & Betts Corporation, Electronics Division,
1001 Frontier Road, Bridgewater, NJ 08807 201-685-1600.

Thomas&Betts

Thomas & Betts facilities in **Australia:** Wyong North N.S.W., 43 53 2300; **Canada:** Ontario, 416-568-9765; **France:** Rungis Cedex, 1-46 87 23 85; **Hong Kong:** Kowloon, (852) 3-7391286; **Italy:** Milan, 02-61 20 451; **Japan:** Tokyo, 3 791 6411; **Mexico:** Naucalpan, 905 393 85 10; **Singapore:** 747 0244; **Spain:** Barcelona, 03-3 00 22 52; **Sweden:** Upplands Vasby, 07 60-8 81 10; **Taiwan:** Taipei, 2 713 0509; **United Kingdom:** Dunstable 0582-608101; **West Germany:** Egelsbach, 0 61 03-40-40.

9-Pin Dot-Matrix Printer

- *25 functions available via front-panel control*
- *Offers 213 cps in draft mode*

The 200GX 9-pin dot-matrix printer delivers 213 cps in draft mode and 40 cps in near-letter-quality mode. You can select more than 25 printer functions, including print color, pitch, five resident fonts, and top-of-form adjustments, from a menu slide switch on the front panel. A paper-parking feature allows you to switch between continuous paper and single sheets. $299.

Citizen America Corp, 2401 Colorado Ave, Suite 190, Santa Monica, CA 90404. Phone (213) 453-0614. FAX (213) 453-2814.

Circle No. 364



Midrange Computers

- *CPU architecture implemented on one chip*
- *Deliver 5 MIPS*

The Eclipse MV/5500 DC midrange computer uses a single-chip, 32-bit CMOS microMV Eclipse processor and furnishes 5 MIPS. It provides 16M to 32M bytes of main memory, which is expandable in 8M-byte increments. It supports as many as 144 asynchronous ports, in addition to multichannel and multiprotocol communications and as many as seven mass-storage peripherals. Contained in a pedestal unit that fits under a desk or table, the system is suitable for stand-alone and networked configurations. Packaged in a 10½-in.-high, NEMA-standard rack-mount chassis, the Eclipse MV/9500 features as much as 128M bytes of main memory, expandable in 8M- or 32M-byte increments. As many as 14 I/O boards can be configured on the main chassis, providing 256 directly connected terminals and 76.8G bytes of Winchester disk storage. The MV/5500 DC, with 16M bytes of memory, a 320M-byte disk, and operating-system right-to-use license is $53,100; the MV/9500, with 8M bytes of memory and operating-system right-to-use license costs $62,000. Delivery, 60 days ARO.

Data General Corp, 3400 Computer Dr, Westboro, MA 01580. Phone (508) 898-4051.

Circle No. 365

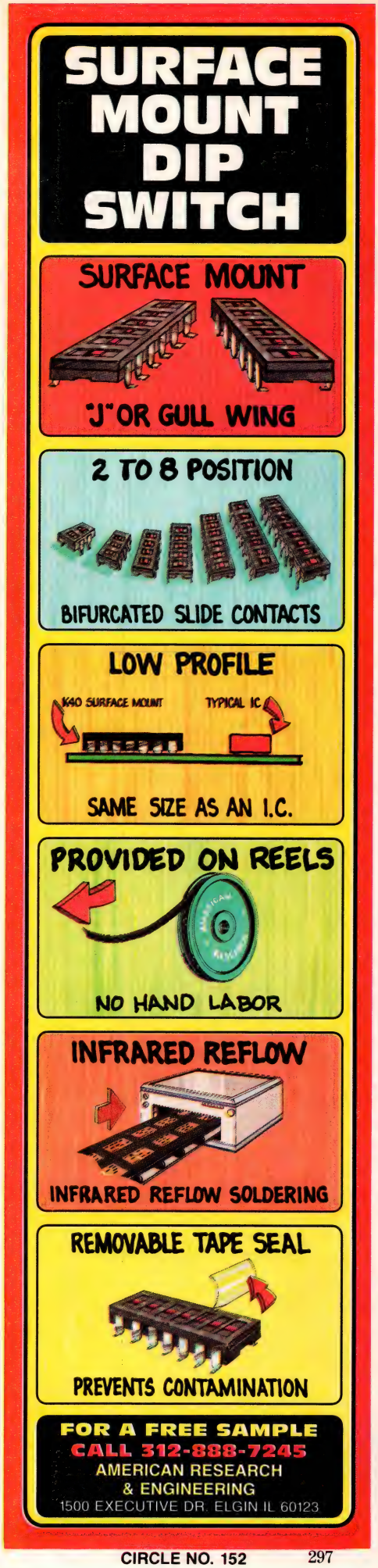
Single-Channel Serial Controller

- *Comes with standby mode*
- *Conserves space, power, and logic*

The μPD72002 single-channel serial controller for data-communications applications offers synchronous data-link control (SDLC), high-level data-link control, sync and async protocol control, two baud-rate generators, and a pair of transmit data-length registers. It features speeds to 2.5M bps and a 12.5-MHz clock. The CMOS part comes with standby mode to reduce power consumption, operates in an SDLC loop mode, can be interfaced to most microprocessors, and provides direct DMA interface to 71071 and 8237 DMA controllers. In a 40-pin DIP or 44-pin quad flatpack, $5.50; in a 44-pin plastic leaded chip carrier, $5.90 (OEM qty).

NEC Electronics Inc, Box 7241, Mountain View, CA 94039. Phone (415) 960-6000. TWX 910-379-6985.

Circle No. 366



CIRCLE NO. 152

AT&T's new datacom ICs take the high cost out of high speed.



AT&T's new 41 Series of differential quad line drivers/receivers and dual transceivers reach 400 Mb/s with substantially reduced EMI.

Our new datacom ICs do more than offer one of the industry's highest data rates and shortest propagation delays.

Their unique design can take you to 400 Mb/s on common twisted pair—at low EMI levels. This makes them an affordable alternative to fiber, when fiber's other benefits aren't needed.

In system use, they decrease EMI levels up to 30 db compared with standard 26LS TTL ICs. This sharply reduces cabinet design costs. And they meet ESDI standards, making them ideal for disk drive applications.

41 Series devices are pin-for-pin compatible with 26LS ICs—so they're easy to use. They help reduce board complexity and cost via on-chip termination and line-impedance-matching resistors. And they come in space-efficient, surface-mount SOJ and SOIC packages as well as standard DIPs.

Not exactly what you need? Create your own custom version quickly and easily by using our standard cell library.

Call **1 800 372-2447** for our databook on 41 Series components, in stock today at Hamilton/Avnet and Schweber.

The components of success.

AT&T
The right choice.

© 1990 AT&T © The Walt Disney Company

CIRCLE NO. 152

AT&T's Datacom ICs: high-speed, low EMI performance

Chart below shows resultant data rates when using a 41 Series driver with various lengths of 26 AWG twisted pair cable terminated with a 41 Series receiver in split termination. Maximum bit rate is the point at which the 41 Series receiver output data eye is reduced 20% from ideal.

MAXIMUM DATA RATE VERSUS LINE LENGTH

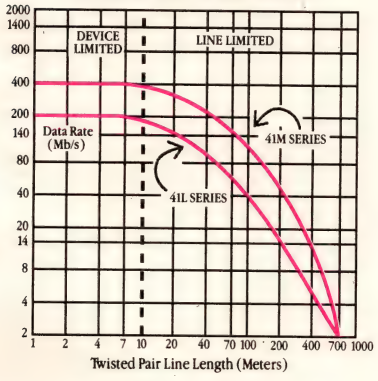


Chart below compares typical propagation delay of AT&T's 41 Series devices to industry standard 26LS and DS8923A devices.

PROPAGATION DELAY (ns)

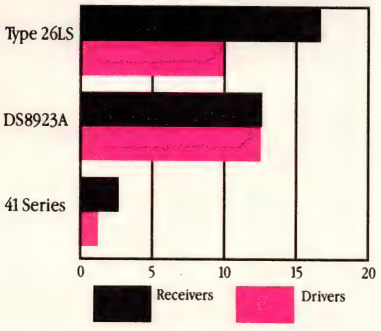
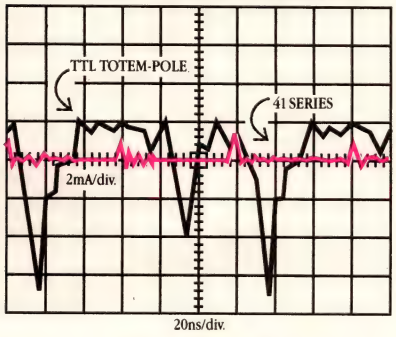


Chart below compares the driver common mode output current levels for the 41 Series and available industry TTL equivalents. Lower Icm results in low EMI.

COMMON-MODE CURRENTS



CIRCLE NO. 153

Dual-Modem Card

- *Allows 14.4k-bps transfer*
- *Automatic dialing and answering*

The RMD 3264 dual-modem card for the RMD 1690 chassis is for central-site locations requiring many point-to-point V.32 leased-line or dial modems providing network management. It works with the vendor's Communications Management Series 910 network-management system, the VA930 security card, and the VA990 chassis controller. You can double the number of modems you place in the 1690 card cage from 16 to 32. The card supports the enhanced V.32 mode, allowing transfer to 14.4k bps. It also supports CCITT recommendations V.33, V.32, V.23, V.22, V.22 bis, and V.21, as well as Bell modem types 103, 212A, and 208A/B. Features include automatic dialing and answering; automatic speed identification of the called or calling modems; V.54 diagnostics; error control with either LAP-M (link access protocol—modem) V.42, or MNP (Microcom Networking Protocol) classes 2, 3, and 4; and data compression with either V.42 bis or MNP Level 5. Other features include leased-line automatic dial backup and restore; switched network automatic redial; and V.13 simulated carrier operation. $2495.

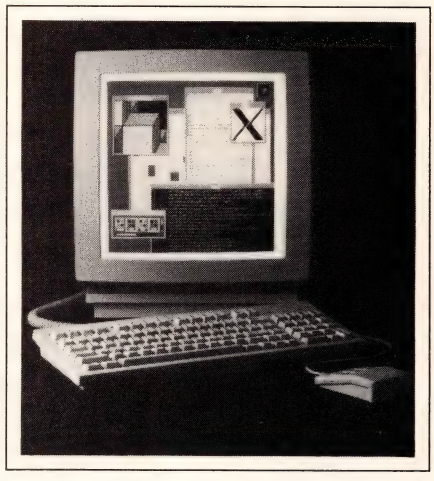
Racal-Milgo, Box 407044, Fort Lauderdale, FL 33340. Phone (305) 846-1601. **Circle No. 367**

Fiber-Optic I/O Link

- *Boards are I/O mapped*
- *Diagnostics and example drivers included*

The Model 501 link consists of two boards, each installed in a separate IBM PC/AT-compatible computer. The boards are I/O mapped and can accommodate 8- or 16-bit operation. The link comes with a disk containing a collection of functions for building application-specific device drivers. You need a duplex 62.5/125-μm glass fiber-optic cable terminated with ST-style connectors to connect the two cards. You can order the cards in a standard 5m length or custom lengths to 1 km. Data is sent over the cable to the remote computer via an I/O write instruction from the local computer to the local adapter board. The local board sends the data to the remote board, where it is stored in a 512-byte FIFO data buffer. An optional software driver performs error checking and error recovery on the interfaces between the two cards. The link achieves a 2M-byte/sec burst throughput rate. 2-card set, $1795.

Bit 3 Computer Corp, 8120 Penn Ave S, Minneapolis, MN 55431. Phone (612) 881-6955. FAX (612) 881-9674. **Circle No. 368**



Compact Monochrome Terminal

- *Uses 15-MHz MC68020 μP*
- *Offers expanded-memory capability*

The 16-in.-diagonal NCD16e terminal provides a 1024 × 1024-pixel, 100-dpi bit-mapped display and supports as much as 8M bytes of dynamic RAM. The display has a 70-Hz refresh rate for flicker-free operation. The terminal, which employs a Motorola MC68020 running at 15 MHz, supports Ethernet, thin Ethernet, and RS-232C/RS-422 communications, and is available with

a choice of keyboards, including PS/2, Unix, and VT220 styles. NCD16e, with 2M-byte RAM, $3200.

Network Computing Devices Inc, 350 N Bernardo Ave, Mountain View, CA 94043. Phone (415) 694-0650. FAX (415) 961-7711.

Circle No. 369

Mass-Storage Card

- *Features 640k-byte static memory*
- *Measures 4.2×5.5 in.*

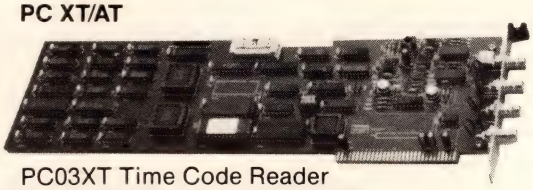
The 6C22 is a PC-compatible CMOS CPU that includes nonvolatile mass storage. You can partition its 640k bytes of static memory into different amounts of system RAM and nonvolatile disk-emulator storage. The BIOS supports booting from the on-card disk emulator, which can use battery-backed CMOS RAM, EPROM, or EEPROM. Total current drain is less than 120 mA at 5V. The 10-MHz, V40-based card provides as much as four times the performance of an IBM PC/XT. It also features three timer channels, three DMA channels, eight vectored interrupts, and a PC/XT-compatible keyboard port. An on-board asynchronous serial port and battery-backed clock/calendar reduce the number of I/O cards needed in most systems. In industrial environments, the 6C22 uses a power-on reset circuit and watchdog timer. $322 (100).

Mesa Electronics, 1329-D 61st St, Emeryville, CA 94608. Phone (415) 547-0837. **Circle No. 370**

• SYNCHRONIZE PROCESSORS
• TIME TAG DATA

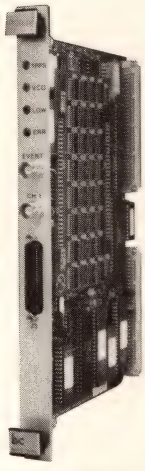
BUS LEVEL TIME CODE PRODUCTS

PC XT/AT



PC03XT Time Code Reader

VME bus



PC03V Time Code Processor

IMMEDIATE SOLUTIONS TO YOUR TIMING PROBLEMS

Our off-the-shelf VMEbus and PC XT/AT bus level time code translators and generators are a convenient, accurate means of synchronizing data processing systems to each other or to standard time of day satellite transmissions.

A time code generator or satellite receiver supplies Time of Day (TOD) and synchronization data via a single coaxial cable connecting all processors. Inside each processor, one of our time code 'readers' decodes the time code signal and supplies TOD across the bus. One millisecond accuracy is commonly achieved. One microsecond is achieved with proper choice of time receiver and code type.

IMMEDIATE DATA SHEETS—

Call or fax a request to us for any of these FAX SPECs:

PC XT/AT:
PC03XT Time Code Reader
PC05XT Time Code Generator

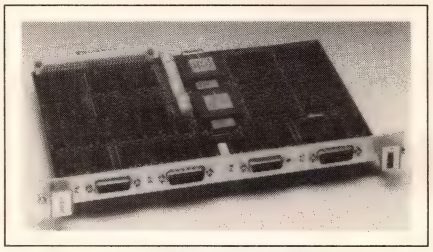
VMEbus:
PC03V Time Code Processor
PC26V Time Display

Other:
M80D-LU Time Display
Synchronization App. Note
Model 9390 GPS Satellite Receiver



BANCOMM
DIVISION OF DATUM, INC.
6541 Via del Oro, San Jose, CA 95119
CALL: (408) 578-4161
FAX: (408) 578-4165

CIRCLE NO. 154

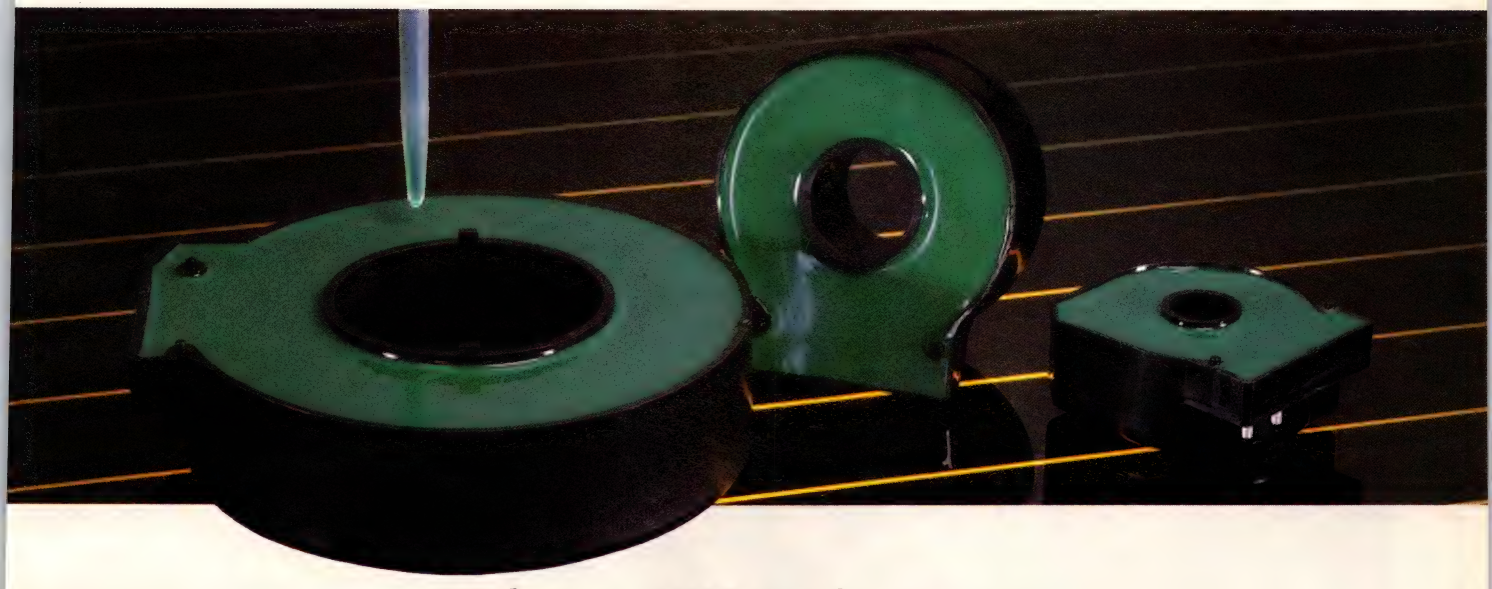


Floating-Point Processor Boards For VMEbus

- *For 25M to 50M flops*
- *Use 80-nsec DSP32Cs*

The ZPB3210 Series boards offer 32-bit processing using the AT&T WE 80-nsec DSP32C. The ZPB3211 uses one floating-point processor operating at 50 MHz with a 64k-byte static RAM and buffered serial I/O ports. These features let the board complete 25M flops. For applications needing increased processing power, the ZPB3212 has two DSP32C processors, each with a 64k-byte static RAM for 50M flops. Data can be transferred to and from either board by the VME parallel port or the high-speed serial bus. Separate serial buses for each DSP32C allow parallel processing of separate multiple data I/Os or serial

The Encapsulant Problem Solvers.



With over 2,700 products, we've got one for you.

A case in point:

When an OEM manufacturer of power distribution systems needed a specialized encapsulant for torroidal coils, they called Emerson & Cuming. Their requirements specified an epoxy-based, single-component product which could eliminate meter/mix/dispense equipment, yet cure at a low temperature and possess exceptional thermal shock characteristics. The solution—one of our STYCAST® series encapsulants.

Emerson & Cuming offers thousands of standard products and the ability to customize for your specific application. We have the encapsulant, adhesive or coating you need to write your own success story.

To get a free selector guide or product sample for evaluation, give us a call.

1-800-832-4929.

Encapsulants • Adhesives • Coatings

EMERSON & CUMING™
a GRACE company

You'll like our chemistry.

© 1990, Emerson & Cuming, Inc.

CIRCLE NO. 155

processing of one I/O. The manufacturer supplies a utilities program, utilities library, and example programs. ZPB3211, $3495; ZPB3212, $5495.

Burr-Brown Corp, Box 11400, Tucson, AZ 85734. Phone (800) 548-6132; in AZ, (602) 746-1111. FAX (602) 889-1510. **Circle No. 371**

3½-In. Disk Drives

- *234M to 422M bytes of storage*
- *Have SCSI-2 controllers*

A family of three 3½-in. hard-disk drives offers 234M bytes (the C2233S), 328M bytes (the C2234S), and 422M bytes (the CS2235S) of storage capacity. Each device features a SCSI-2 controller; the company expects to offer an IBM PC/AT controller later this year. The drives have an average random-seek time of 13 msec, an average latency of 8.3 msec, and controller overhead of <1 msec. The data-transfer rate is 3M bytes/sec in asynchronous mode and 5M bytes/sec in synchronous mode. The estimated MTBF is 150,000 hours. Evaluation units should be available this summer. C2235S, $1620; C2234S, $1380; C2233S, $1050.

Hewlett-Packard Co, 19130 Pruneridge Ave, Cupertino, CA 95014. (Phone local office).

Circle No. 372

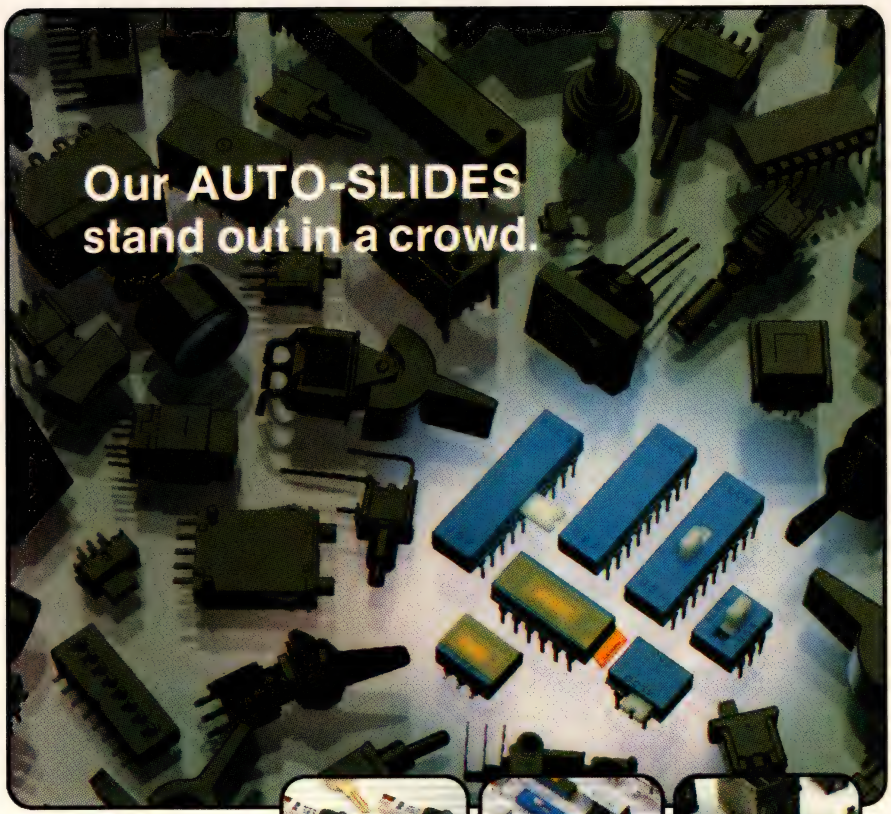
Manufacturing Kit For 486 AT Mother Board

- *Includes manual and fabrication and assembly drawings*
- *Comes with tested 486 mother board*

The TWA-486/AT manufacturing kit provides all the material you need to produce IBM PC/AT-compatible mother boards based on Intel's 486 processor. It includes a tested 486 mother board (with no CPU or memory); contact master positive film; manufacturing instructions; and seven PC disks that contain schematics, a net list, and fabrication and assembly drawings. The mother board uses the 2-chip HiB/486 AT chip set from OPTi and an optimized 486 BIOS. The board's baby AT form factor allows its use in standard PC/AT cabinets as well as in small-footprint baby AT cabinets and minitowers. The board can hold as much as 16M bytes of on-board memory and runs without wait states at 25 MHz using 80-nsec dynamic RAM. The kit has a 3-month warranty. From $20,000.

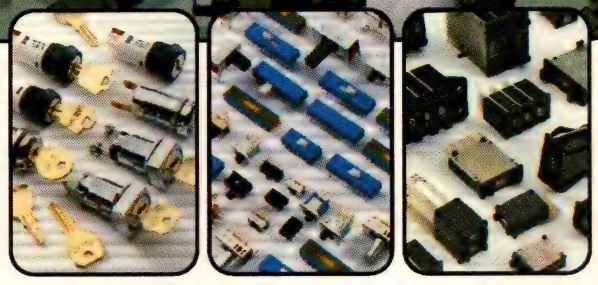
Tidewater Associates Inc, 3101 Whipple Rd #27, Union City, CA 94587. Phone (415) 487-5650.

Circle No. 373



Industry's First Sealed, SMD Slide Switch

- Auto-insertable and surface mount compatible
- 2, 4 or 6 pole versions with top or side actuation
- Sealed immersion cleanable versions available
- High reliability bifurcated gold or silver contacts



AUGAT/ALCOSWITCH offers a full product line including...

Keylocks Slides Pushwheel

For your free catalog, product samples, applications help, or a quotation, call or write AUGAT/ALCOSWITCH, 1551 Osgood Street, No. Andover, MA 01845 USA,
Tel: (508) 685-4371, TLX: 275423, FAX: (508) 686-9545

AUGAT® ALCOSWITCH®
Quality and Innovation

AUGAT INTERNATIONAL SALES OFFICES

AUGAT LIMITED - ENGLAND	(011) 4490676655
AUGAT SA - FRANCE	(011) 33146683090
AUGAT GMBH - WEST GERMANY	(011) 49896129090
AUGAT AB - SWEDEN	(011) 468960270
AUGAT SRL - ITALY	(011) 3939654100
AUGAT ISRAEL	(011) 9723492173
AUGAT ELECTRONICS INC. - CANADA	(1) 4166771500
AUGAT RTY LTD. - AUSTRALIA	(011) 6129050533
AUGAT KK - JAPAN	(011) 810550897911

CIRCLE NO. 156



Radstone supplies Norden Systems (US) and Marconi Command and Control Systems (UK) with bulk storage memory units developed for the MLRS fire control computer. On time. On budget.

MIL-Spec. VMEbus

The Sure-Fire Solution To Cost and Lead-Time Problems In Military Computer Applications

Now there is a new generation of Mil-Spec computer hardware. For systems integrators with tactical computer applications who need a sure-fire solution fast, Radstone has the answer — a complete range of field-proven Mil-Spec, 32-bit VME boards.

All you need to build tomorrow's military systems today, available off-the-shelf, 68020 processors, memory and I/O modules, Multiprocessor capability. On board diagnostics. Real-time Ada and C software support. A choice of Mil-qualified system enclosures.

This total capability is designed for projects where lower development costs, shorter and more predictable timescales are important. Developed by Radstone, one of the world's largest manufacturers of VME boards with leading edge design resources to match. Built by Radstone, in a facility approved to NATO AQAP1 standards. Supported by Radstone, with 30 year's experience of military systems applications.

Call us now for your copy of the new PMV 68 MIL-STD-VME systems guide. Let us show you how we put the sure-fire solution into action.

RADSTONE TECHNOLOGY

UK *Water Lane, Towcester, Northants, NN12 7JN, (0327) 50312*
USA *20 Craig Road, Montvale, NJ 07645, (201) 391-2700*
France *'Miniparc' 6 avenues des Andes, 91940 Les Ulis, (1) 64.46.04.03*
Germany *Bahnhofstraße 38, D-6090 Rüsselsheim (061 42) 6 80 04*

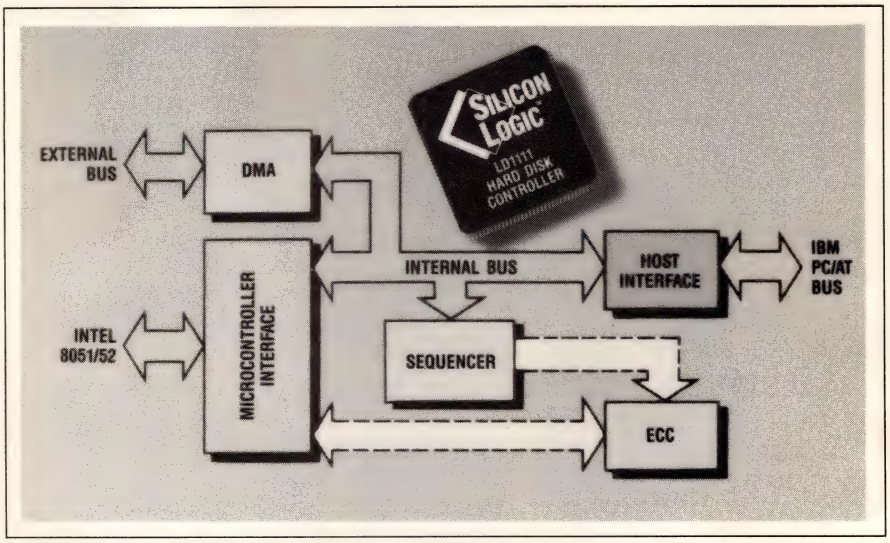
NEW PRODUCTS

INTEGRATED CIRCUITS

Hard-Disk Controller

- *Handles data-transfer rates to 24M bps*
- *Supports ST506/412 and ESDI formats*

The LD1111 hard-disk controller IC operates at the maximum bus speed of an IBM PC/AT and handles disk data-transfer rates as fast as 24M bps. The chip was specially designed to function with existing PC/ATs and compatibles, and the Unix, Xenix, MS-DOS, and new OS-2 operating systems. The device, which supports the ST506/412 and all ESDI formats in a 1:1 interleave, interfaces with Western Digital's WD-37C65A and National's DP-8473B floppy-disk controller. The device also interfaces with the AMD-9582 and the SSI-534 data separators, for Winchester data separation and data synchronization. The LD1111, which also supports a 2k- to 64k-byte buffer, comes in a 128-pin quad flatpack designed for surface mounting. $15 (1000).



Silicon Logic, 550 E Brokaw Rd, San Jose, CA 95161. Phone (408) 441-1615. FAX (408) 954-0727.

Circle No. 394

Be An Author!

When you write for EDN, you earn professional recognition. And you earn $75 per published magazine page.

EDN publishes how-to design application information that is read by more than 137,300 electronics engineers and engineering managers worldwide. That's an audience that could belong to you.

If you have an appropriate article idea, send your proposal and outline to: **Joan Morrow** , 275 Washington Street, Newton, MA 02158-1630.

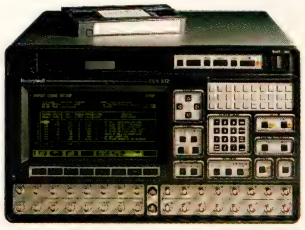
For a FREE EDN Writer's Guide—which includes tips on how to write for EDN and other technical publications—please circle number 800 on the Information Retrieval Service Card.

EDN *First in Readership among Design Engineers and Engineering Managers in Electronics.*



THE ONLY TAPE RECORDER SENSITIVE ENOUGH TO CAPTURE THIS

The Honeywell **Model RSR 512** (Rotary Storage Recorder) makes common sense as well as technical sense. ☐ Its excellent dynamic range, reliable performance and complete package of special features make it hard to beat. Its surprisingly modest price tag makes it hard to resist. And the Honeywell name makes it easy to place confidence in. ☐ A precision voltage recorder, the RSR 512 offers a **70 dB SNR/dynamic range** — a full order of magnitude improvement over today's FM data recorders. ☐ To accomplish this feat, Honeywell has combined the characteristics of FM recording with the added accuracy of digital recording. The **digital technology** incorporated into the RSR 512 provides both analog and digital output, better recording fidelity, and fast, easy data transfer to computers. ☐ Honeywell chose proven, high-quality industrial/broadcast transport technology along with the worldwide standard low-cost ½" **T-120 videocassette medium** for the RSR 512. More than 30 years of design experience in data path electronics have enabled us to develop an advanced digital servosystem using the latest microprocessor controlling, the digital **helical recording** technique used does not restrict all channels to the same frequency response at given tape speed. ☐ With the **programmable bandwidth** of the RSR 512, each channel can be selected for a bandwidth appropriate to the input data, from dc to 80 kHz in 13 binary steps. ☐ In addition, the RSR 512 offers a **512:1 speed range** in ten binary steps. When you apply this speed range to the videocassette format, the recording time can vary from 50 minutes to over 426 hours, depending on the number of channels used and the bandwidths selected. ☐ The RSR 512 is available in 8-, 16-, 24- and 32-channel configurations. More channels can be added by using an optional auxiliary housing. ☐ When you attach a modest price tag to such features, performance and reliability, the Honeywell Model RSR 512 displays an unmatched sensitivity to value. ☐ For more details, contact **Darrell Petersen** at Honeywell Inc., Test Instruments Division, P.O. Box 5227, Denver, Colorado 80217-5227. (303) 773-4835. Asia Pacific (852-5) 8298298. Canada (613) 224-3822. Europe 32 (02) 728-24-79. Japan (81)-3-477-5141.





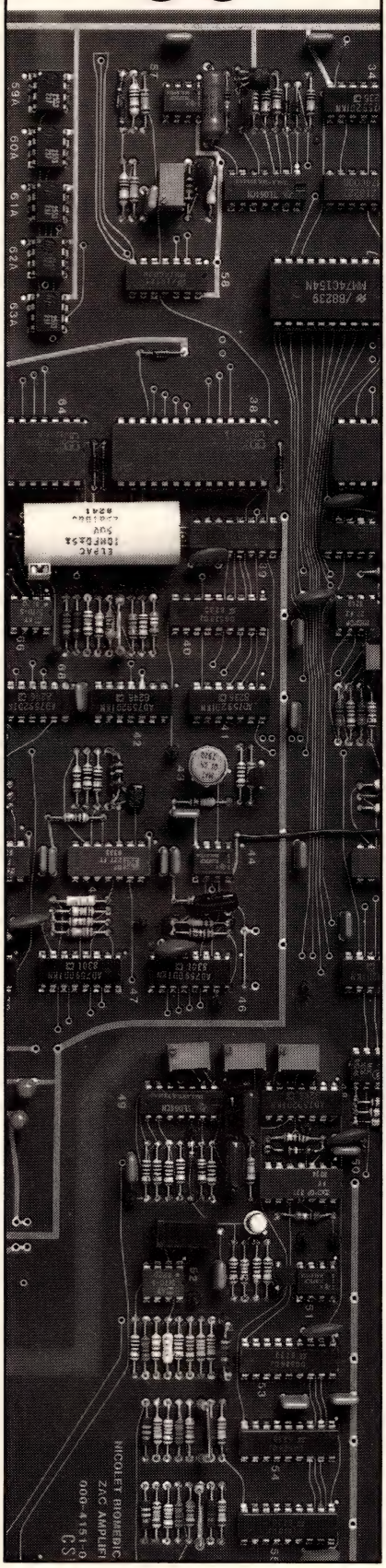
IS ALSO REMARKABLY SENSITIVE TO THIS.

Honeywell

HELPING YOU CONTROL YOUR WORLD

CIRCLE NO. 159

Bigger.



Picture-Insertion ICs

- *Work with both analog and digital TVs*
- *Provide two formats for the inserted picture*

Combining memory, control, digital signal processing, and D/A converters in a single circuit, the SDA 9088 Picture Insertion Processor (PIP) accommodates picture signals based on different standards and synchronization principles. The PIP handles both 50-Hz, 625-line and 60-Hz, 525-line signals. The field frequency can be either 50 Hz or 60 Hz, allowing the insertion of a phase-alternation-line signal (European standard) in an NTSC (US standard) main picture. Standard receivers may have analog main-picture as well as small color-picture insertion. For these applications, the SDA 9087 triple A/D converter accepts color differential signals and luminance information for processing in the PIP. The SDA 9087 generates the line-locked clock frequency and synchronizes the incoming color and luminance signals. Two formats are available for the inserted picture: 1/9 and 1/16 the size of the main picture. The PIP can display the insert in any of the four corners. A 16×16-step positioner for each corner permits adjustment to the particular set's picture geometry. SDA 9088, $22.72; SDA 9087, $6.06 (1000).

Siemens Components Inc, M/S M16P001, 2191 Laurelwood Rd, Santa Clara, CA 95054. Phone (408) 980-4501. **Circle No. 395**

Programmable Reference

- *Has 2.5 to 36V range*
- *Multiple package options*

The LT1431 is a precision adjustable-reference and amplifier combination with a 100-mA current-sink capability. The device comes in an

DC-DC CONVERTERS TO 25 WATTS



The Low Cost Solution To Your Voltage Conversion Requirements!

ERG's DC-DC Converters are designed for operation from low level DC supply voltages. Outputs are available from 5 VDC to 1500 VDC in Single, Dual or Center-Tapped options. Encapsulated in epoxy resin, converters are PCB mountable in 3, 6, 12, and 25 watt packages.

Ask About Our E400 Series DC-DC Regulators!

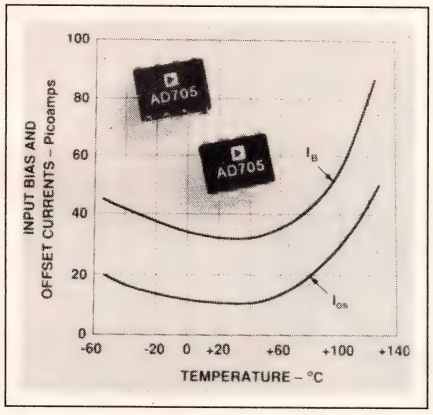
ERG Endicott Research Group, Inc.
2601 Wayne Street, P.O. Box 269, Endicott, NY 13760
607-754-9187 FAX 607-754-9255

©1990 ERG Inc.

For orders up to $250 VISA MasterCard

8-pin SO surface-mount package or an 8-pin miniature DIP that provide access to numerous internal functions. It is also available in a 3-pin TO-92 package that's pin compatible with the industry-standard 431 reference. On-chip divider resistors let you configure the reference as a 5V shunt regulator with a 1% initial tolerance. By adding two external resistors, you can set the output voltage to any value between 2.5 and 36V. The LT1431 also has adjustable current-limit and frequency-compensation nodes, which make the device easier to use in many applications. TO-92, $0.95; 8-pin DIP, $1.25.

Linear Technology Corp, 1630 McCarthy Blvd, Milpitas, CA 95035. Phone (800) 637-5545; in CA, (408) 432-1900. FAX (408) 434-0507. **Circle No. 396**



Precision Bipolar Op Amp

- *Low input-bias current*
- *Low offset voltage*

The monolithic AD705 bipolar op amp has a maximum input-bias current of 150 pA and maximum drift of 0.3 pA/°C from −40 to +85°C. Also featured is a maximum offset voltage of 35 μV and offset drift of 0.6 μV/°C. Other important specifications include CMRR of 132 dB and PSRR of 129 dB. The AD705 is an improved pin-compatible replacement for the industry standard LT1012 and OP-97, but with a higher minimum open-loop gain of 400V/mV. The AD705, which operates from ±15V supplies and dissipates 650 mW, is available in three temperature grades and two performance grades. Package options include 8-pin plastic DIPs, hermetic ceramic DIPs, and SOIC packages. From $0.89 (1000).

Analog Devices Inc, 181 Ballardvale St, Wilmington, MA 01887. Phone (508) 658-9400.

Circle No. 397

10-Bit Flash ADCs

- *Include track-and-hold circuit*
- *Achieve throughput rates to 200 kHz*

Using a 2-step flash algorithm, the HI-7151 and HI-7152 10-bit A/D converters can achieve throughput rates to 200 kHz. The HI-7151 and HI-7152 feature 10- and 5-μsec conversion times, respectively. The devices are accurate to <½ LSB, without requiring offset or gain adjustments. The use of standard μP control signals simplifies bus interfacing, and digital outputs are byte organized for interfacing to 8- or 16-bit control systems. Included on each converter is a track-and-hold (T/H) amplifier, which consists of two high-speed amplifiers. Using an internal hold capacitor, these amplifiers can acquire input signals to 78 kHz. The T/H circuit can handle input signals to ±2.5V directly. HI-7151, from $10; HI-7152, from $15 (1000).

Harris Semiconductor, Box 883, Melbourne, FL 32901. Phone (800) 442-7747, ext 1064.

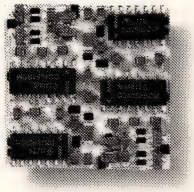
Circle No. 398

±600V-Supply Op Amp

- *Has 1000V output swing*
- *Provides 75 mA of output current*

Supplied in a package that takes up <3^2-in. of space, the PA89 features a 1200V supply rating (±600V). With 75 mA of continuous output current available, the op amp can drive capacitive loads with values as high as 1000 pF. The op amp's

Better.



BETTER BECAUSE IT'S SMALLER.
Space is the first thing you save at PHM. You can expect a 1:10 reduction in size with our hybrids, 1:4 with surface-mount boards.

BETTER BECAUSE IT'S FASTER.
You also save time. Send us your design parameters and you'll get a prototype in 4 to 6 weeks (sooner if you need a miracle).

BETTER BECAUSE IT'S CHEAPER.
Time is money — see above. A PHM prototype typically is less than $3,000.

BETTER BECAUSE IT'S BETTER.
Our products deliver exceptional performance and reliability. That's because we use only the latest techniques in design and manufacturing.

BETTER GIVE US A CALL.
See why companies like Tektronix, Motorola, RCA and Hewlett Packard come to us with their biggest problems. Call 1-800-622-5574 for a free quote or literature package.

10575 SW Cascade Blvd. Portland, OR 97223
(503) 684-5657 FAX (503) 620-8051

PACIFIC HYBRID MICROELECTRONICS
We do small miracles.
Copyright © 1990 Pacific Hybrid Microelectronics

CIRCLE NO. 162



CONQUER SPACE

With Samtec .050" Centerline Interconnects

Now, thanks to recent advances by Samtec, the challenge of continued miniaturization is being met with a new family of connectors. Samtec .050" interconnect solutions are helping accelerate miniaturization by satisfying the need where space is at a premium.

Samtec .050" interconnects include:

- Standard and low profile socket strips
- Single and double row headers
- IDC and soldered cable assemblies
- LCD connectors
- Through-hole and surface mount designs
- .050" x .100" and .050" x .050" grid designs

Given the drive toward smaller sizes, the future for .050" interconnects is as limitless as space itself. Arm yourself with the tools necessary to conquer your PC Board space challenges. Call or write today for the new Samtec Micro Catalog.

812-944-6733





samtec IS SUDDEN SERVICE

New Albany, Indiana USA • Sacramento, California USA • Cumbernauld, Scotland UK • Singapore

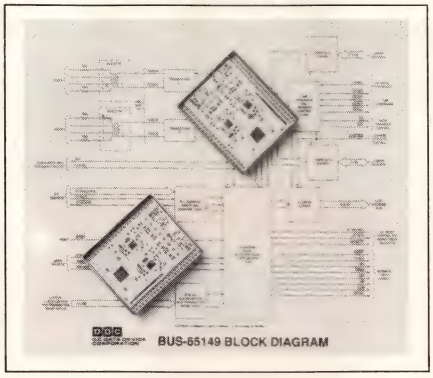
SAMTEC, INC. P.O. Box 1147 • New Albany, IN 47151-1147 USA • Phone 812-944-6733 • Fax 812-948-5047 • TWX 810-540-4095 • Telex 333-918

CIRCLE NO. 163

power bandwidth is typically 5 kHz at output swings of 1000V p-p. Using two PA89s in a bridge mode provides output swings of more than 2000V. A cascoded-FET input stage results in a bias current of only 50 pA for the standard grade. The premium-grade PA89A has a typical bias current of only 3 pA (10 pA max). PA89, $310.50; PA89A, $403.65 (100). Delivery (OEM qty), six weeks ARO.

Apex Microtechnology Corp, 5980 N Shannon Rd, Tucson, AZ 85741. Phone (800) 421-1865.

Circle No. 399



Avionics Bus Interface

- *Implements MIL-STD-1553*
- *Supports DMA and shared RAM*

Designed specifically for use in avionics systems, the Bus-65149 bus interface implements all dual-redundant MIL-STD-1553A/B message codes. The hybrid IC supports MCAIR A3818, A5232, and A5690; General Dynamics 16PP303; and Grumman SPG151A protocols through a pin-selectable universal transceiver. The IC can also make any command illegal through the use of an external PROM, PAL, or RAM device. The Bus-65149, which contains internal address and data buffers, supports both DMA and shared-RAM interfaces and is compatible with all μPs. The device

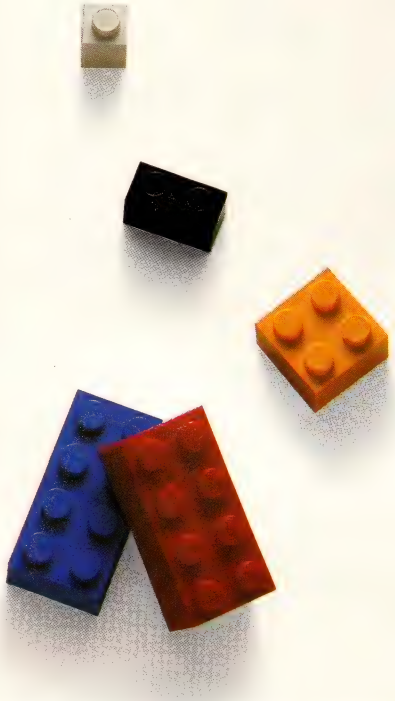
TANTALUM CHIP CAPACITORS FOR SURFACE-MOUNT DEVICES



MATSUO ELECTRONICS
2134 Main Street, Suite 200 (714) 969-2491
Huntington Beach FAX (714) 960-6492
California 92648

CIRCLE NO. 164

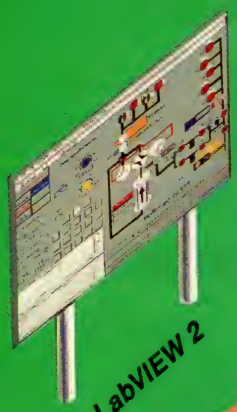
You're About To See A New Interconnect System That's As Modular As This.

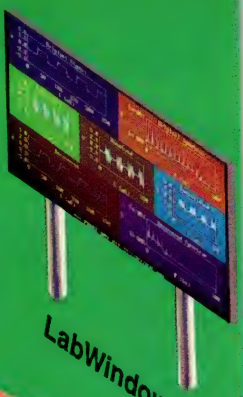


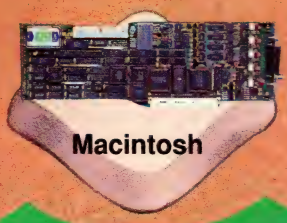
DuPont Electronics
Share the power of our resources.

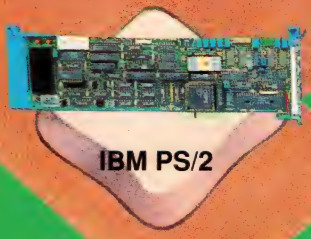
DUPONT

When It Comes to Data Acquisition We've Got All the Bases Covered



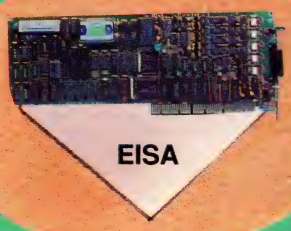








Why Play Ball With Anyone Else?



Our lineup for the season:

- Boards for all PC platforms
- Self-calibration
- 8 to 16-bit resolution
- DMA on all computers
- Toll-free technical support
- 33.33 MFLOPS digital signal processing
- Signal conditioning and antialiasing filters
- Multiboard timing and synchronization with RTSI®
- LabVIEW® 2, LabWindows®, VisionScope™, and LabDriver® software

Many vendors can get you to first base with PC/XT/AT boards. We're the *only* company that will take you all the way home, with boards for the PC, Macintosh, PS/2, and EISA bus.

SCOREBOARD

Board	Computer	Analog In	Sample Rate	Resolution (Bits)	Analog Out	Digital I/O	Counter/ Timers	DMA Direct to Memory
Lab-PC	PC/XT	8	62.5k	12	2	24	3	√
Lab-SE	Macintosh SE	8	125k	8	2	24	3	–
AT-MIO-16	PC/AT	16	100k	12	2	8	3	√
MC-MIO-16	IBM PS/2	16	100k	12	2	8	3	√
NB-MIO-16X	Macintosh II	16	55k	16	2	8	3	√
NB-A2000	Macintosh II	4	1M	12	–	–	–	√
EISA-A2000	EISA	4	1M	12	–	–	–	√

To see the rest of our data acquisition team, call for *FREE* catalog.

NATIONAL INSTRUMENTS®
The Software is the Instrument™
6504 Bridge Point Parkway
Austin, TX 78730-5039

Nihon National Instruments K.K. (Japan) (3) 788-1922
National Instruments of France (1) 4865-3370
National Instruments of Italy (2) 4830-1892
National Instruments United Kingdom (06) 355-23-545

(800) 433-3488 (U.S. and Canada) • (512) 794-0100

CIRCLE NO. 165

provides complete error detection, including sync, encoding, parity, bit- and word-count, undefined commands, and RT-to-RT transfer errors. The Bus-65149, which comes in a 2.375×2×0.25-in. 90-pin package, operates over the −55 to +125°C temperature range and is available screened to MIL-STD-883B. From $1195 (1 to 9). Delivery, 90 to 120 days.

ILC Data Device Corp, 105 Wilbur Pl, Bohemia, NY 11716. Phone (516) 567-5600. FAX (516) 567-7358. **Circle No. 400**

Half-Bridge Drivers In SOIC Packages

- *Replace two MOSFET devices*
- *Optimized for motor-drive applications*

Housed in compact 8- and 16-pin SOIC packages, the Si9951DY, Si9954DY, and Si9956DY are half-bridge drivers optimized for low-voltage motor-control applications. These surface-mount devices can replace two 4-pin DIPs with one smaller SOIC package and eliminate the need for through-hole assembly. The 8-pin Si9951DY and 16-pin Si9954DY are complementary half-bridge drivers rated at 18V/1.8A and 50V/2.6A, respectively. The 8-pin Si9956DY, which you can configure as a half-bridge driver, contains two 20V/1.8A-rated electrically isolated n-channel MOSFETs. All of the devices feature a copper lead frame that optimizes thermal performance. The Si9951DY, $0.90; the Si9954DY, $1.25; the Si9956DY, $1.30 (OEM qty).

Siliconix Inc, 2201 Laurelwood Rd, Santa Clara, CA 95054. Phone (800) 554-5565, ext 1400; in CA, (408) 988-8000. **Circle No. 401**

Properties of Gallium Arsenide
1990 Edition

This is a completely revised, updated, and much expanded version of the 1986 book which is now commonly used by GaAs researchers worldwide. More than 70 researchers from the USA, Europe, and Japan have pooled their expertise into over 180 specialized articles or Datareviews on the properties, growth, processing, and applications of this intensely studied material.

As well as reviewing and evaluating the properties of GaAs and AlGaAs, the book provides up-to-date reports on growth techniques, oxidation, passivation, ion implantation, rapid thermal annealing, etching, epitaxial liftoff and GaAs-on-Si. Applications in electronics and optoelectronics are also surveyed. In particular, there is an up-to-date report on the recent breakthrough in optical computing.

Available in August 1990.
Approximately 700 pages, casebound. $290.00
Telephone and credit card orders accepted.

inspec

INSPEC Department/ IEEE Service Center
445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331
Telephone: (201) 562-5554 Fax: (201) 981-0027

CIRCLE NO. 166

You're About To See A New Interconnect System That Brings High-Density Packaging Down To This.



DuPont Electronics
Share the power of our resources.

DUPONT

NEW PRODUCTS

TEST & MEASUREMENT INSTRUMENTS

Line-Frequency Gaussmeter

- *Measures from 1m Gauss to 20 Gauss at 50 or 60 Hz*
- *Operates from a 9V alkaline battery*

The ELF-50D handheld meter measures the strength of magnetic fields generated by ac power lines and equipment connected to them. You can obtain the meter calibrated for 50 or 60 Hz. Calibration is traceable to the National Institute of Standards and Technology. The unit, which includes a 3½-digit LCD and a low-battery indicator, operates for approximately 50 hours from a 9V alkaline battery. There are two ranges. On the more sensitive one, the unit can resolve 1m Gauss. On the higher range, it can measure fields as large as 20 Gauss. $225.

Walker Scientific Inc, Rockdale St, Worcester, MA 01606. Phone (800) 962-4638; in MA, (508) 852-3674. FAX (508) 856-9931.

Circle No. 374



Thermocouple Calibrators

- *Range for type J thermocouples, 0 to 1000°F*
- *Range for type K thermocouples, 0 to 2000°F*

The CAL-22J and CAL-22K thermocouple calibrators are handheld units powered from a pair of AA cells or from a wall-mounted power supply. The 22-J unit covers 0 to 1000°F with a second, switchable range from −50 to +950°F. The 22-K unit covers 0 to 2000°F with a second range from 100 to 2100°F. The units conform to the latest standards of the American Society for Testing Materials for conversion of temperature to millivolts by thermocouples. They incorporate cold-junction compensation accurate to ±0.25°F/°F of departure of the calibrator from 75°F. Accuracy in measuring temperature changes is ±0.01% of span/°F of departure of the calibrator from 75°F ±0.1% of span ±1°. $184.

Acculex, 440 Myles Standish Blvd, Taunton, MA 02780. Phone (508) 880-3660. TLX 503989.

Circle No. 375

ADC And DSP Coprocessor For Macintosh SE/30

- *Performs 25M flops*
- *Transfers data at 8M bytes/sec*

The MacDSPSE/30 card plugs into the Apple Macintosh SE/30 computer. The card includes a 150-kHz, 16-bit ADC; a 16-bit DAC; a 50-MHz floating-point DSP chip; and 256k bytes of zero-wait-state static RAM. The board transfers data to and from the Macintosh's 68030 processor and main memory at 8M bytes/sec and performs 25M flops. An array-processor library allows programs written in C, Pascal, and Basic to take full advantage of the board. The vendor also offers a real-time signal-analysis software package and an integrated C compiler for developing custom DSP applications. $2695; signal-analysis software and array-processor library, $495 each; C compiler, $1500.

Spectral Innovations, 4633 Old Ironsides Dr, Suite 450, Santa Clara, CA 95054. Phone (408) 727-1314. FAX (408) 727-1423.

Circle No. 376

Microcontroller Socket Converter

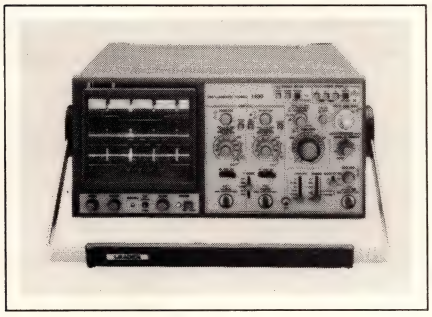
- *Designed for use with in-circuit emulators*
- *Accepts 84-pin PGA plug; converts to 68-pin PLCC pinout*

The 84-PGA/68PLCC-A is a socket converter designed for use with in-circuit emulators. It accepts a pin-

grid array plug or an IC having 84 pins and plugs into a socket intended for a 68-pin plastic leaded chip carrier. A single jumper on the converter lets you configure it for use with either an 80C515 or 80C537 microcontroller. The converter is designed for frequent insertion and removal from a target system without damage to itself or the system. $210.

EDI Corp, Box 366, Patterson, CA 95363. Phone (209) 892-3270. FAX (209) 892-3610.

Circle No. 377



3-Channel 100-MHz Scope

- *Has dual timebase*
- *Provides 500 μV/div max sensitivity*

The 1100 is a 100-MHz, 3-channel, dual-timebase analog oscilloscope. It can display six traces and has a maximum vertical sensitivity of 500 μV/div. Among the scope's features are alternate triggering, alternate timebase, and variable trigger holdoff. Sync-separator circuits simplify viewing of TV signals. $1545.

Leader Instruments Corp, 380 Oser Ave, Hauppauge, NY 11788. Phone (800) 645-5104; in NY, (516) 231-6900. **Circle No. 378**

Handheld Fiber-Optic Test Set

- *Includes LED sources at 850, 1300, and 1550 nm*
- *Has adapters for commercial connectors*

The FOT-30 optical-attenuation test set is a handheld, digital-readout unit powered by a 9V alkaline battery. It includes three LED light sources with wavelengths of 850, 1300, and 1550 nm. The vendor supplies adapters for all commercial fiber-optic connectors. The unit operates in single and multiple modes and measures attenuation in dB and power in dBm and watts. Calibration is traceable to the National Institute of Standards and Technology. Zeroing is automatic, and dynamic range exceeds 50 dB. $995 to $3000.

Exfo Electro-Optical Engineering, 352 St-Sacrement Ave, Quebec City, PQ, Canada G1N 3Y2. Phone (418) 683-0211. FAX (418) 683-2170. **Circle No. 379**

Graphical Interface For Data Acquisition

- *Interface is the same under MS-DOS, Unix, and OS/2*
- *Lets you configure your application by connecting objects*

IconView is an object-oriented, graphical user interface for the data-acquisition and control software packages, Labtech Notebook and Labtech Acquire. The interface provides the MS-DOS, Unix, and OS/2 versions of the packages with a similar look and feel. With IconView, you configure the packages to perform the functions you desire by pointing at icons with a mouse and connecting them with lines drawn on the screen. Under MS-DOS, version 3.0 or higher, the interface supports hundreds of objects. Under Unix (IBM AIX, DEC Ultrix, or Apollo Domain/OS) and OS/2 (4M bytes of RAM required), it supports thousands of objects. The interface works with color displays and permits a work area of unlimited size through which you can scroll. Labtech Notebook, from $995; Labtech Control, from $3995.

Laboratory Technologies Corp, 400 Research Dr, Wilmington, MA 01887. Phone (508) 657-5400. FAX (508) 658-9972. **Circle No. 380**

Text continued on pg 317

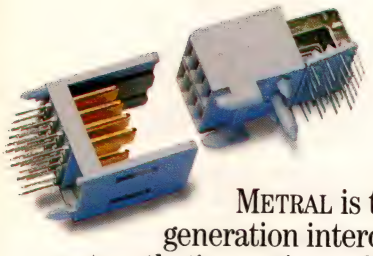
You're About To See A New Interconnect System That's As Multi-Functional As This.



DuPont Electronics
Share the power of our resources.

DUPONT

Introducing The Universal



METRAL is the next generation interconnect system that's meeting today's need for greater density, modularity, flexibility, and functionality.

And that's just the beginning.

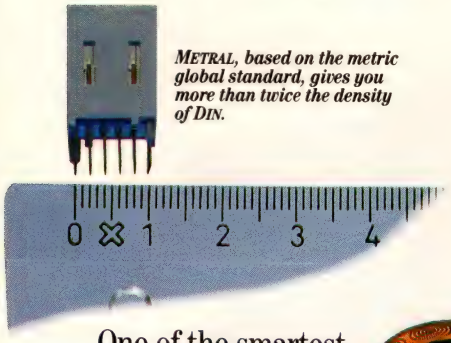
METRAL cuts costs by shortening the design cycle.

It reduces risk by being flexible enough to allow for design changes.

And METRAL is universal enough to use in electronic packaging designs from modems to mainframes.

With all these advantages, it's no wonder METRAL was selected by IEEE as the interconnection standard for Futurebus+.

Over 2 Times The Density of DIN.



METRAL, based on the metric global standard, gives you more than twice the density of DIN.

One of the smartest features of METRAL is that it's designed with today's—and tomorrow's—high density requirements in mind.

METRAL connectors are based on a 2.0 millimeter grid (an excellent balance of density, cost and durability), and provide up to 456 signal positions on a double Eurocard. Which means, in the same amount of space, METRAL packs more than twice the position density of DIN 41612.

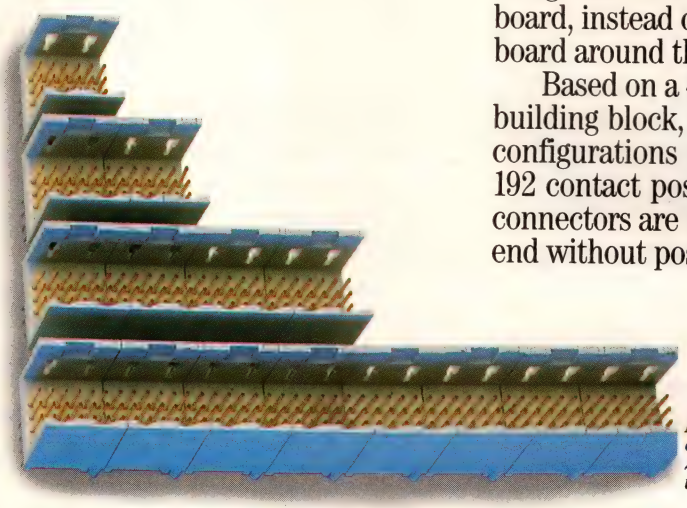


With This Much Modularity, You Can't Lose.

Because of its uniform module design, METRAL is remarkably adaptable. This allows you to design the connectors around the board, instead of designing the board around the connectors.

Based on a 4x6 position building block, METRAL offers configurations of 24, 48, 96 and 192 contact positions. And the connectors are stackable end-to-end without position loss. You can use the same footprint for signal and power modules. If you don't need a module, the space saved on the board can be used for something else.

METRAL also has keying and coding features for mistake-proof assembly.



METRAL offers stackable end-to-end configurations of 24, 48, 96 and 192 contacts—without position loss.

Affordable, cost-effective density like that makes METRAL indispensable if you want the most value possible from available real estate.

To put it another way, the more functions you pack on a board, the more you need METRAL.



Du Pont METRAL*. Interconnection System.

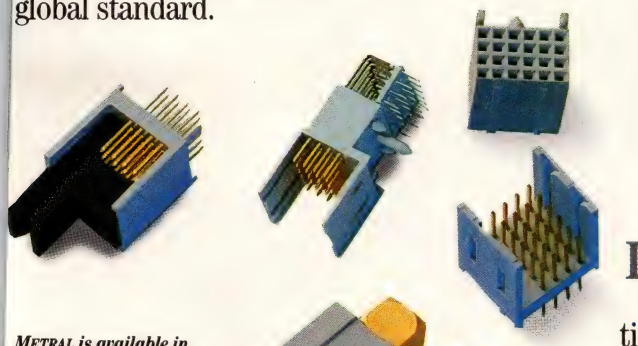
The Universal Standard.

Thanks to its "building block" approach, METRAL affords designers limitless creativity by standardizing the configuration of the connectors. That means you can standardize across your entire product line—whether data processing, telecommunications or instrumentation.

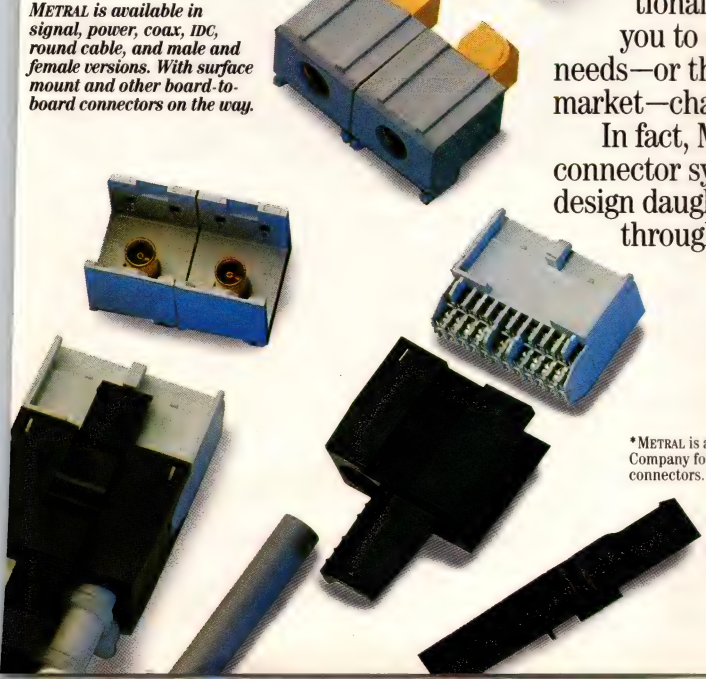
What's more, since METRAL connectors can be qualified as a system, you can reduce approval time.

And with metric standardization on the way, designing with METRAL makes even more sense. Because METRAL already meets the metric global standard.





METRAL is available in signal, power, coax, IDC, round cable, and male and female versions. With surface mount and other board-to-board connectors on the way.



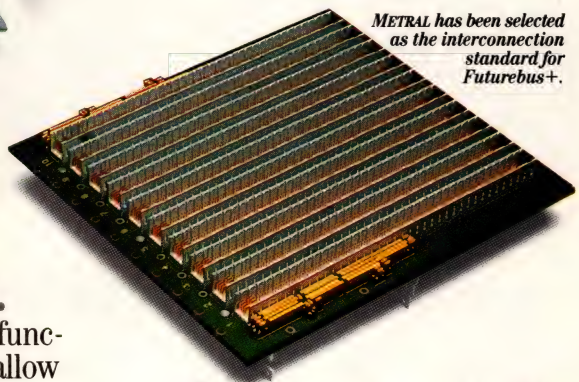
METRAL Does It All.

METRAL is multifunctional enough to allow you to expand as your needs—or the needs of the market—change.

In fact, METRAL is the first connector system that lets you design daughter cards for through-hole or surface mount without redesigning the backpanel system.

METRAL is available in signal, power, coax, IDC, round cable and male and female solder-to-board versions. And shielded cable connectors, surface mount, fiber optic, press-fit and high speed board-to-board connectors are on the way.

Make The Move To METRAL.



METRAL has been selected as the interconnection standard for Futurebus+.

The first step is to call **1-800-237-4357.** We'll send you more information about the one connector system that can meet your needs today—and tomorrow—for more density, modularity and flexibility. METRAL.

Du Pont Electronics
Share the power of our resources.

DU PONT

*METRAL is a trademark of the Du Pont Company for its family of electronic connectors.

Because we tapped the inner secrets of tantalum. . .

Tantalum pellet magnified 10,000 times.



Our capacitors offer out-of-this-world performance.

NEC tantalum pellet technology magnifies capacitance power without increasing capacitor size.

Our SVE-Series tantalums incorporate a built-in fuse to minimize damage from reverse current. Yet they require no extra space on your boards, and maintain compatibility with our R-Series. SVE capacitors are engineered for noise absorption in computers, terminals and measuring equipment. We offer 21 types with ratings from 1.0 to 33 μF, and from 10 to 50 V DC.

Our R-Series extended-capacitance chips now offer up to 4.7 μF power in the industry's smallest case (1.6 x 3.2 x 1.2 mm). The extended R-Series consists of 58 device types with ratings from 0.1 to 100 μF, and from 2.5 to 35 V DC.

NEC's total production of tantalum caps exceeds one billion chips per year. Quality is equally high, backed by 100% burn-in and exceptionally low field-failure rates. If you want capacitors that give you maximum performance per micron, take a close look at NEC.

For fast answers, call us at:

USA Tel:1-800-632-3531. TWX:910-379-6985. W. Germany Tel:0211-650302. Telex:8589960. The Netherlands Tel:040-445-845. Telex:51923. Sweden Tel:08-753-6020. Telex:13839. France Tel:1-3946-9617. Telex:699499. Italy Tel:02-6709108. Telex:315355. UK Tel:0908-691133. Telex:826791. Hong Kong Tel:755-9008. Telex:54561. Taiwan Tel:02-719-2377. Telex:22372. Korea Tel:02-551-0450. Fax:02-551-0451. Singapore Tel:4819881. Telex:39726. Australia Tel:03-267-6355. Telex:38343.

CIRCLE NO. 167

NEC

Thermocouple Data-Acquisition System

- *Has 16 thermocouple and eight high-level inputs*
- *Includes PC bus card and external unit*

The EZ-Lab thermocouple data-acquisition system is based on an IBM PC-compatible computer. The system includes both a PC bus I/O card and an external unit. It has 16 low-level thermocouple inputs and eight differential high-level inputs that can monitor current loops. The system also has eight digital I/O lines and comes with Labtech Notebook data-acquisition software. The 2.5× 10×4-in. external unit houses the thermocouple multiplexer and screw terminals for attaching signal leads. Cold-junction compensation handles seven types of thermocouples. The software compensates for thermocouple nonlinearity, and the A/D converter resolves signal changes small enough to represent 0.1°C temperature changes. $1995.

Adac Corp, 70 Tower Office Park, Woburn, MA 01801. Phone (800) 648-6589; in MA, (617) 935-6668. **Circle No. 381**



Automated Test System

- *Based on computer that's compatible with IBM PC/AT*
- *Includes instrumentation cards and software*

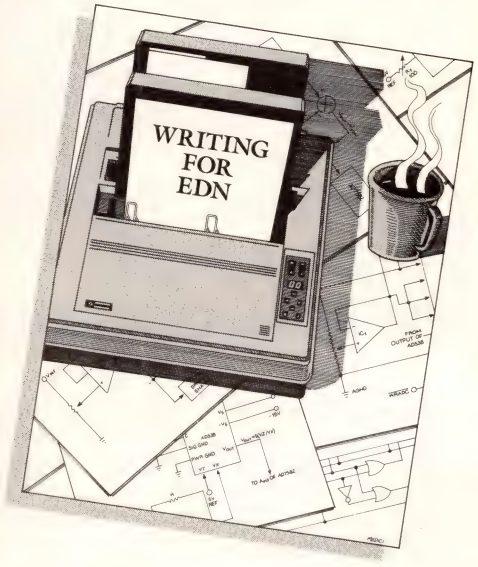
The ATE-100 system consists of an IBM PC/AT-compatible computer, a selection of the vendor's plug-in instrumentation cards, and optional controlling software. The system can hold eight of the I/O cards. One card can acquire 16 channels of analog data at 40M samples/sec. Another generates eight arbitrary analog waveforms or a 64-bit-wide TTL digital pattern. The system allows synchronizing all waveform generation cards to a common clock and triggering all data-acquisition channels from a common source. Software drivers are compatible with Turbo Pascal, Turbo-Basic and Microsoft C, and Turbo-C. $4950; software, $1995; oscilloscope data-acquisition card, $1995; waveform generator, $2495; software drivers, $1000.

Gage Applied Sciences Inc, 2695 Paulus St, Montreal, PQ, Canada H4S 1E9. Phone (514) 337-6893. FAX (514) 337-8411.

Circle No. 382

Turn Good Ideas Into Good Articles

With EDN's FREE Writer's Guide!



Would you like to get paid for sharing your clever engineering ideas and methods with your professional colleagues? If so, then send for EDN's new FREE writer's guide and learn how.

You don't need the skills and experience of a professional writer. And you don't need to know publishing jargon. All you *do* need are a little perseverance, your engineering skills, and the ability to communicate your ideas clearly.

Our new writer's guide takes the mystery and intimidation out of writing for a publication. It shows you how to write for EDN using skills you already have. Plus, it takes you step-by-step through the editorial procedures necessary to turn your ideas into polished, professional articles.

Get your FREE copy of EDN's writer's guide by circling number 800 on the Information Retrieval Service Card or by calling (617) 964-3030.

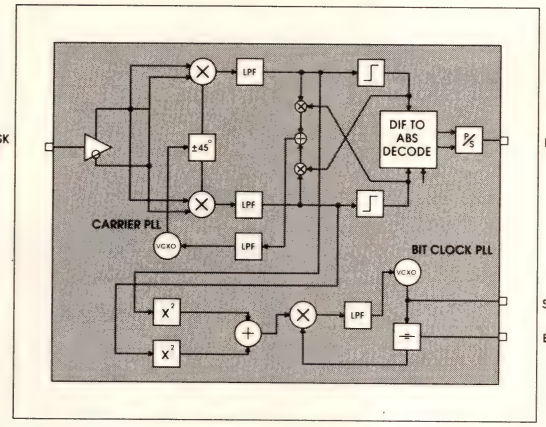
30-MHz Network Analyzer

- *Displays 501 data points on 8-in. CRT*
- *Measures at 300 μsec/point*

The MS3401A network analyzer measures amplitude, phase, and impedance from 10 Hz to 30 MHz. It acquires data as fast as 300 μsec/point, or as slowly as 27.5 hours for a full sweep; it displays 501 points on an 8-in. CRT. Dynamic range is 100 dB, and phase-measurement range is ±180°. You can control the unit via an IEEE-488 port, and you can also store 10 measurement setups on a plug-in memory card. A personal test automation (PTA) option lets the instrument make automated measurements without an IEEE-488 controller. $16,130; PTA option, $2530. Delivery, 12 weeks ARO.

Anritsu America Inc, 15 Thornton Rd, Oakland, NJ 07436. Phone (800) 255-7234; in NJ, (201) 337-1111. **Circle No. 383**

MAS 7A101
DEMODULATOR IC ...



... FOR NICAM QPSK SUBCARRIER SIGNAL

- all demodulation Nyqvist filters on chip - user selectable 100 % or 40 % cosine roll-off response.
- independent pll for carrier recovery and for bit clock regeneration.
- can be used also for other similar QPSK demodulation applications.Carrier frequency up to 7 MHZ
- minimum external parts count

State-Of-The-Art Analog/Digital Asics
MICRONAS
MEMBER OF THE NOKIA GROUP
P.O. Box 51, Kamreerintie 2, SF-02771 Espoo, Finland
Tel.Int.+358-0-80521,Fax+358-0-8053213,Telex 1000691,Teletex 244-1000691

CIRCLE NO. 169



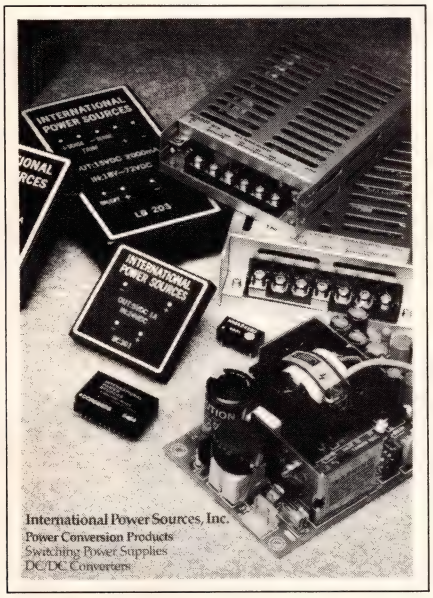
Handheld DMM

- *Has 26 ranges*
- *Resists dropping, water, and overloads*

The 2860 Survivor is a rugged, handheld digital multimeter with a 0.8-in.-high display and 26 ranges. The meter survives 5-ft drops; is sealed to resist rain, grease, and dirt; and withstands overloads caused by high-energy fusing and overload protection. DC accuracy is 0.5%; ac accuracy is 1.25% from 40 to 500 Hz. The unit can measure current to 20A and resistance to 20 MΩ. It provides an audible continuity indication and tests diodes by forcing a maximum current of 1.5 mA. The vendor claims that the unit's 5-year warranty is an industry first. $99.

B&K Precision, 6740 W Cortland St, Chicago, IL 60635. Phone (312) 889-9087. **Circle No. 384**

LITERATURE



Power Supplies Cataloged

A 40-pg catalog describes switching power supplies and dc/dc converters. The selection covers power-conversion products having output ranges from 1 to 200W, hybrids, and wide-input-range products. The book presents products used for telecommunications, process control, and other electronic applications.

International Power Sources Inc, 200 Butterfield Dr, Ashland, MA 01721. **Circle No. 402**

Hard-Cover Directory Lists Waveform Instruments

The 1990 catalog, *Reference Guide to Digital Waveform Instruments*, presents digital oscilloscopes, modular waveform digitizers, and signal sources. New product offerings include the Model 9424 quad-channel 350-MHz digital oscilloscope, the Model 7200 modular digital oscilloscope, the Model 9112 arbitrary function generator, and the Model 7900 Series wavecorder mass-memory digitizing system. A tutorial section deals with topics such as fundamentals of digital oscilloscopes and waveform digitizers, benefits of long memories in digital oscilloscopes, and how to trigger on the most elusive events. Some of the offerings in the 10 appendices include a glossary of terms; applications literature and publications; attenuation of cables; conversions and resistor codes; a product index; and a subject index.

LeCroy, 700 Chestnut Ridge Rd, Chestnut Ridge, NY 10977. **Circle No. 403**

How To Use Z280 Software

The Guide to Z280 Applications Development application note provides examples and suggestions for using Z280 software. Topics include using the memory manager, user and system modes, internal I/O, cache, upgrade paths, and selecting development tools.

Softaid Inc, 8930 Route 108, Columbia, MD 21045. **Circle No. 404**

Power-Supply Specification Noted

Application note No. 7, *Specifying Switching Power Supplies: A System Designer's Checklist*, allows you to check off design requirements and can help you save time and money. The note includes a section on misunderstood power-supply features and a discussion of methods for reducing costs.

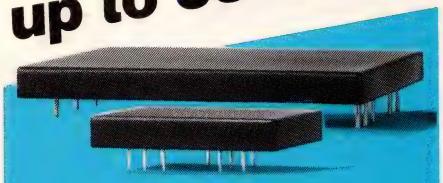
Computer Products, Power-Conversion America, 3785 Spinnaker Ct, Fremont, CA 94538. **Circle No. 405**

Fast-Charge Circuits Detailed

AN37: Fast-Charge Circuits for Ni-Cad Batteries provides schematics and notes on the construction of proven, thermally based NiCd battery chargers. The note discusses both linear and switched-mode chargers. The note desribes circuits of either type for charging batteries committed to ground.

Linear Technology Corp, 1630 McCarthy Blvd, Milpitas, CA 95035. **Circle No. 406**

Lowest Profile
0.5" ht.,
up to 55 Watts



PICO
AC-DC
Power
Supplies

- Input Voltage 90 to 130 VAC (47/440Hz)
- Single, Dual, Triple Outputs
- 1200V Rms Isolation
- Low Isolation Capacity Available
- Continuous Short Circuit Protection
- High Efficiency
- Fully Regulated Voltage Outputs
- Operating Temperature −25°C. to +70°C. with No Heat Sink or Electrical Derating Required
- Expanded Operating Temperature Available (−55°C. to +85°C. ambient)
- Optional Environmental Screening Available

PICO manufactures complete lines of Transformers, Inductors, DC-DC Converters and AC-DC Power Supplies

Delivery—stock to one week

SEE EEM, THOMAS REGISTER OR SEND DIRECT FOR FREE PICO CATALOG

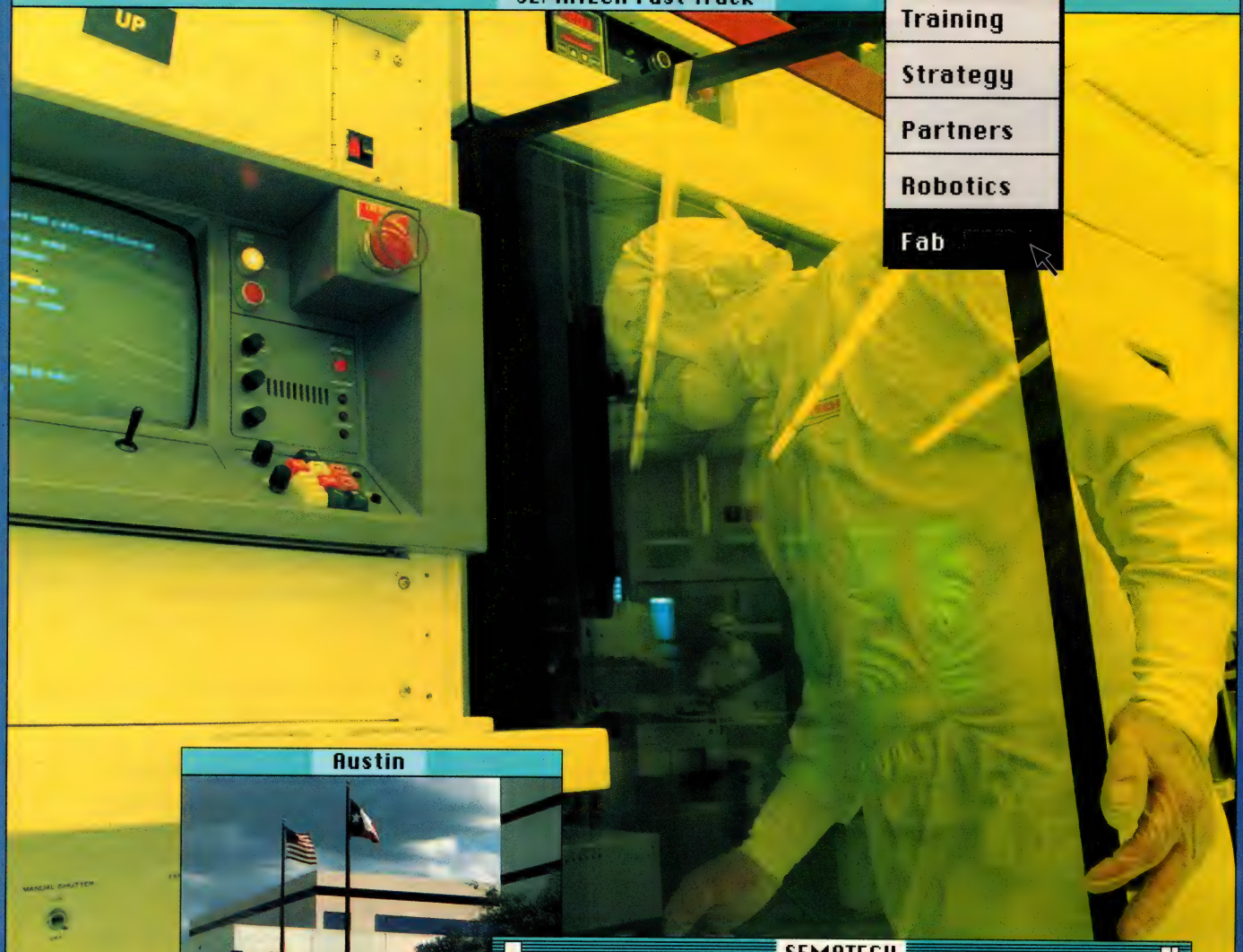
PICO Electronics, Inc.
453 N. MacQuesten Pkwy. Mt. Vernon, N.Y. 10552
Call Toll Free 800-431-1064
IN NEW YORK CALL 914-699-5514

CIRCLE NO. 143

Ideas Options Milestones Technology Innovation

SEMATECH Fast Track

Training
Strategy
Partners
Robotics
Fab



Austin

Join the Team!

SEMATECH offers opportunities for those who want to work with the best:

Lithography Engineers
Wet Process Engineers
Plasma Process Engineers
PVD Engineers
Metrology Engineers
Equipment Development Engineers
Thermal Process Support Engineers
Reliability Engineers
Yield Defect Management Engineers
Diffusion Engineers
Product Engineers
Process Integration Engineers
Parametric Test Engineers
Failure Analysis Engineers
Senior Staff Statisticians
Quality Facilitation Engineers
Manufacturing Systems Engineers
Calibration Manager
Modeling and Simulation Engineers

Send your resume to:
PAT COCKBURN
Staffing Manager
SEMATECH, Staffing Dept.
2706 Montopolis Dr., Dept. EDN
Austin, TX 78741

SEMATECH

Accelerating the Fast Track.

It's the best of the best: **SEMATECH,** accelerating the fast track by bringing the power of the best companies, the best people, the best ideas and technology together.

Renewed world competitiveness and renewed infrastructure for the United States semiconductor industry begin at **SEMATECH** where outstanding professionals from member companies **AMD, AT&T, DEC, Harris, Hewlett-Packard, Intel, IBM, LSI, Logic, Micron Technology, Motorola, National Semiconductor, NCR, Rockwell,** and **TI** can accept two-year job assignments on the cutting edge of innovation.

SEMATECH—member companies, the American people, distinguished universities, the U.S. Government—the partnership that's making a difference.

For information:
512 356-3500

SEMATECH

Bringing the Best Together

CIRCLE NO. 170



Brochure Discusses Data-Collection Systems

This 6-pg brochure describes on-line data-collection total-system solutions. Information in the pamphlet includes descriptions of the varied applications for which the data-collection systems are used as well as the hardware and software that provide a customized system solution. Also described are the 4-level integrated systems architecture and system-integration services.

Burr-Brown Corp, Box 11400, Tucson, AZ 85734. **Circle No. 407**

Simplifying Design Of Brush DC Motor Drives

Application note AN1078/D, *New Components Simplify Brush DC Motor Drives*, presents a variety of components that make the design of brush motor drives easier. It describes a brushless motor-control IC, multiple power MOSFETs, a MOS turn-off device, and gain-stable optolevel shifters. The note considers topologies that control speed in both directions and operate from a single power supply.

Motorola Literature Distribution, Box 20912, Phoenix, AZ 85036. **Circle No. 408**

Stepping Motors Categorized

This full-line catalog of stepping motors offers application notes and general specifications. It also lists product capabilities such as rated voltage, rate current/phase, winding resistance/phase, inductance, and holding torque. The 40-pg publication describes more than 30 hybrid and permanent-magnet motors. Features and benefits data for each model list step angle, step-angle accuracy, detent torque, temperature rise, ambient temperature range, insulation resistance, dielectric strength, insulation class, switching sequence, radial play, end play, rotor inertia, and weight. For each model the literature includes functional diagrams, torque speed charts, and winding diagrams. Engineering information provides step-motor terminology,

EDN
INFO
CARDS

THE
2¢
SOLUTION

to your marketing budget blues—the EDN Info Card Pack. At 2¢ per name, the EDN Info Card Pack can reach over 123,000 engineering specifiers affordably.

EDN Magazine Edition / News Edition

A Partnership in Power and Prestige Worldwide

GRAYHILL SURFACE MOUNT DIP SWITCHES TAKE 260° OF INFRA-RED IN STRIDE

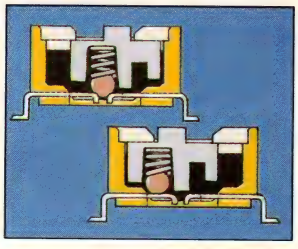


You've put the heat on us to deliver Surface Mount DIP Switches you can process in infra-red convection ovens. We've done it! Our new Series 90H Switches will withstand temperatures of 260°C continuous...the industry's first.

These Surface Mount DIP switches are fully sealed against flux and other contaminants, including the best tape seal anywhere.

After your SMT DIP switches have survived infra-red or vapor-phase processing, you still need peak performance in the field. Grayhill's unique, time-tested spring-and-ball contact design delivers it...high contact pressure, total immunity to shock and vibration.

Strong claims. Yes..., but we've proved them, and so can you. Call Grayhill at (708) 354-1040 for evaluation samples and your free copy of Bulletin 487, describing the Grayhill SMT DIP Switch line.



PEAK CONTACT PERFORMANCE
Spring-and-ball contact design—proven performance in millions of DIP Switches. No contact degradation from heat damage during manufacturing!

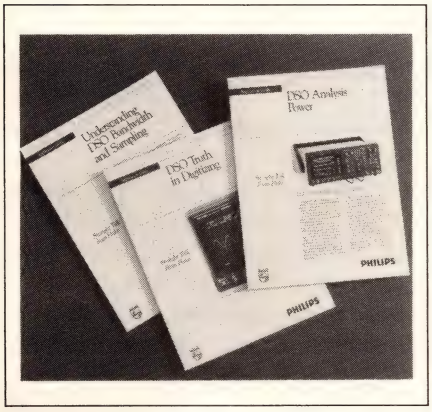
Grayhill INC.
At the Peak of Performance

561 Hillgrove Avenue, P.O. Box 10373
LaGrange, Illinois 60525-0373 USA
Phone: (708) 354-1040
FAX: (708) 354-2820
TLX or TWX: 190254 GRAYHILL LAGE

CIRCLE NO. 172

switching-sequence tables, torque-conversion factors, and moment-of-inertia conversion factors.

NMB Technologies Inc, 9730 Independence Ave, Chatsworth, CA 91311. **Circle No. 409**



Trio Of Notes Discusses Selection And Use Of DSOs

This series of notes explains how DSOs, through increased signal-acquisition power, extensive analysis, automation, and ease of use, replace analog scopes for many applications. The notes provide terms needed to describe the added power provided by DSOs. *Understanding DSO Bandwidth and Sampling* deals with DSO specifications, bandwidth, and sampling speeds and demonstrates how they relate to acquiring single-shot and repetitive signals. *DSO Truth In Digitizing* examines DSO signal-acquisition power, clearly explains critical specifications, and shows how to measure and compare the performance of different models. Finally, *DSO Analysis Power* explains how automatic measurement and calculation allow closer examination of the acquired signal.

John Fluke Mfg Co Inc, Box C9090, Everett, WA 98206.

Circle No. 410

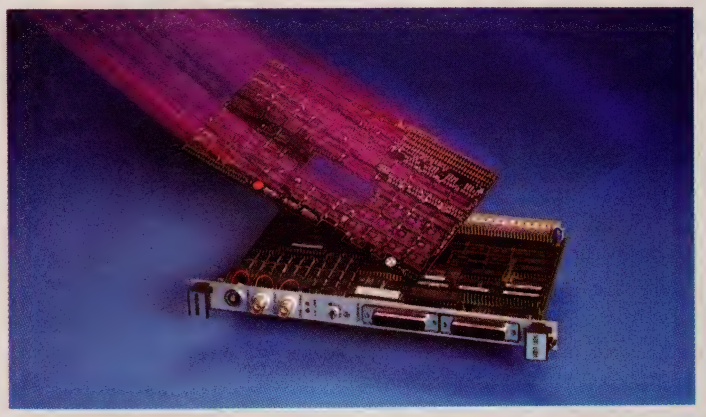
Products For TTL Backplane-Interface Uses

This 160-pg data book deals with a series of products developed for TTL backplane-interface applications. The book details the bus-interface ICs and includes a product-selection section, which provides an index to devices, a product-selection guide, a cross reference, and packaging and ordering information. Other sections provide technical overviews of features, benefits, rating, and characteristics. The technical-data section supplies data sheets. An application-note and dimensional-outline section is also included.

Harris Semiconductor, Box 883, Melbourne, FL 32901.

Circle No. 411

The Modular VME Analyzer System



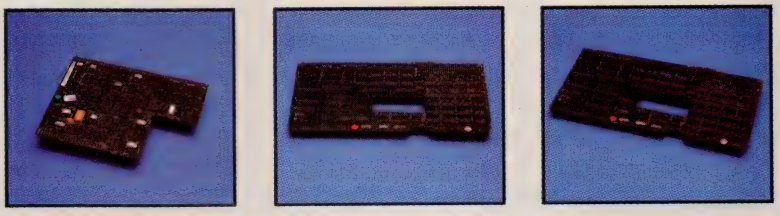
The VSB-PB Subsystem Bus Analyzer piggybacked on the VBT-321 offers 2k of demultiplexed VSB trace, four sequential trigger/qualifier events, time tag, statistics functions, etc.

VMETRO's well-proven VBT-321 VMEbus Analyzer can now be expanded with a full set of powerful add-on modules offering a complete measurement solution for VMEbus development, testing and performance analysis. Operated from an ASCII terminal or PC, all combinations offer unrivaled measurement capability in a single VME slot.

VBAT-PB VMEbus AnomalyTrigger for compliance verification.

XMEM-PB 64K/256K Expansion Trace Memory for the VBT-321.

TIM100-PB 100 MHz VMEbus Timing Analyzer for HW debug.



VMETRO

The Bus Analyzer Specialist

VMETRO A/S
Sognsveien 75, N-0855 Oslo 8, Norway
Tel: +47 2 39 46 90 Fax: +47 2 18 39 38

VMETRO, Inc.
2500 Wilcrest, #550, Houston, TX 77042
Tel: (713) 266-6430 Fax: (713) 266-6919

CIRCLE NO. 173

BOOK REVIEW

Mac reference offers a wealth of code examples

On Macintosh Programming: Advanced Techniques, by Daniel K Allen. 471 pgs; $24.95. Addison-Wesley, Reading, MA, 1990.

I've always believed that the best way to learn programming is first to introduce yourself to the formalities of a language, then to the system you want to program, and finally to practice, practice, practice. It also helps to study examples of good, clean code. This book will appeal strongly to programmers who are searching for a concise, Macintosh-programming reference that provides lots of examples of code in a variety of languages.

The author provides nearly 300 pages of code examples. These examples aren't mere illustrations; they are tools that solve actual problems the author encountered. They show engineers specifically what the Mac can do for them.

Allen grabs the reader's interest at the beginning and doesn't let go. He starts with a brief insider's look at the history of Macintosh development, crediting colleagues along the way for parts they played in shaping the Mac into what it is today. In Chapter 1, he rolls up his sleeves and delves into the intricacies of the Macintosh architecture.

Beginners may find it hard to get past the first chapter without an understanding of C and basic computer-architecture terms. Allen doesn't provide the nitty-gritty information about how to program in C—the book isn't a language tutorial. To get the most use from the book, therefore, readers should understand Pascal, 68000 assembly language, or C, which dominates in his examples. To brush up on C, I recommend that you browse through Brian W Kernighan and Dennis M Ritchie's *The C Programming Language*, 2nd ed (Prentice Hall, Englewood Cliffs, NJ, 1988).

Allen admits that the learning curve for the Mac is very steep. The toolbox routines are exhaustive, and you may be overwhelmed by the Mac's capabilities. Once you recognize and learn the power of the routines, however, you won't want to use brute force to program.

In Chapters 2 through 5, Allen deals with the Macintosh Operating System, Quickdraw, the Macintosh Toolbox, and the Standard Apple Numerics Environment (SANE). Chapter 6 discusses the Macintosh Programmers Workshop (MPW). Chapters 7 through 10 each discuss a specific language: C, assembly, Pascal, and HyperTalk scripting.

The utilities and applications that Allen offers as code examples pertain directly to the topics covered in each chapter. He wrote most of the utilities in the book to solve actual problems and says he has found them to be handy tools that he uses daily. For example, in Chapter 1, which discusses Mac hardware and software architecture, he provides in-depth coverage of the Macintosh A-trap dispatcher—the "Grand Central Station of the Macintosh architecture." After discussing the A-trap, which processes almost all requests for services from the Mac, he includes a helpful utility that looks up A-traps by name or number.

Alas, as with any programming book, there is a typo here and there, so readers should be alert. I found one typo while entering the first long array of the ATrap utility mentioned previously, but in a 4-page A-trap array, one upper-case "S" that should have been in lower case isn't bad.

In Chapter 10, Allen includes an entire application written in HyperTalk. The application, which allows nonprogrammers to do programming, is preceded by a brief historical introduction to HyperCard. From there he moves right into advanced HyperTalk scripting, demonstrating how you can extend HyperTalk's power by writing X-commands and X-functions in C and Pascal.

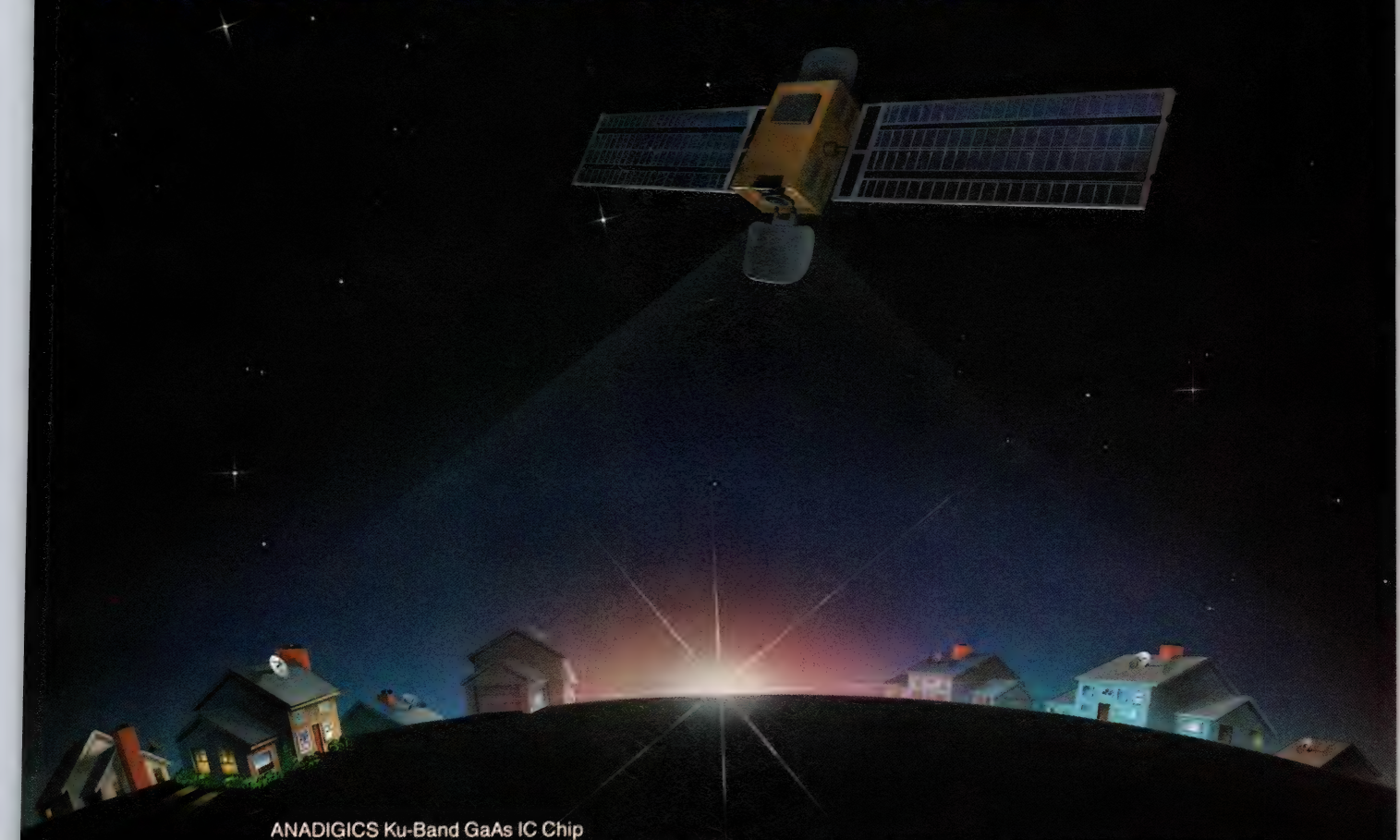
Allen developed the majority of his examples of code using the Macintosh Programmers Workshop. Although having the MPW isn't necessary to study the examples, I suggest getting it if you plan to do serious Macintosh application development or if you just want to take full advantage of the book's examples. You can obtain the MPW by calling the Apple Programmers and Developers Association (APDA, 1-800-282-2732). A disk that contains the source code from the book in the form of MPW text files is available from the author for $20.

The book is intended to be used as a complement to Apple's *Inside Macintosh* reference. Although his book isn't light reading, Allen does succeed in providing a concise companion to the voluminous *Inside Macintosh*. Anyone who has ever searched through the company's many volumes of reference material for the right Toolbox call will appreciate Allen's treatment of toolbox routines.

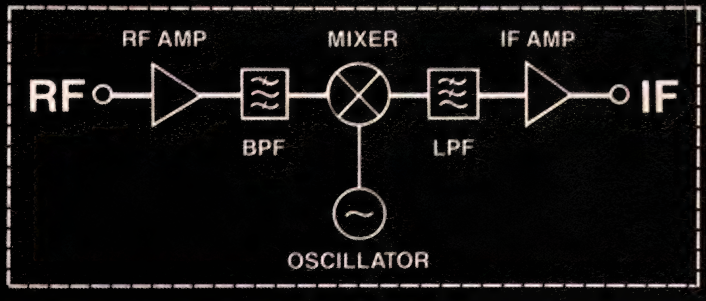
The 27-pg annotated bibliography deserves special note. This feature alone makes the book worth getting; it's the most thorough I've seen in a work on this topic. Its 206 entries include subjects such as algorithms, compiler construction, symbolic manipulation, and artificial intelligence. Only through careful research do you end up with a bibliography this good, a fact that the quality of information in the book reflects. The author also includes an appendix. As a whole, *On Macintosh Programming: Advanced Techniques* is an asset to anyone's Macintosh programming library.—***Richard Miller***

Richard Miller received a BS in Computer Science from Chaminade University (Honolulu, HI). He is a Macintosh consultant.

NOW! HIGH VOLUME–LOW COST DOWNCONVERTER ICs FOR Ku-BAND SATELLITE DISHES



ANADIGICS Ku-Band GaAs IC Chip



MODEL	BANDWIDTH	APPLICATION
AKD 12000	10.95 - 11.70 GHz	Communications/DBS
AKD 12010	11.70 - 12.20 GHz	DBS
AKD 12011	11.70 - 12.50 GHz	DBS (Full Spectrum)

Off-The-Shelf Delivery

Only ANADIGICS gives you downconverter IC chips for less than $10 each ... in quantities of 100,000 ... immediately! They increase reliability, reduce the number of components, shrink overall downconverter size, and cut your engineering and assembly time. The result? With ANADIGICS, you get to market faster, for less, with unmatched reliability. And we'll give you application assistance or a sample downconverter IC with a fixture ready to hook up to your test bench. Call our Marketing Department today at 201-668-5000 or write to ANADIGICS, 35 Technology Drive, Box 4915, Warren, NJ 07060
FAX 201-668-5068

CIRCLE NO. 174

ANADIGICS®

Your GaAs IC Source

From financial flop to Fortune 500

George Hatsopoulos built Thermo Electron on an invention that never sold.

Jay Fraser,
Associate Editor

George Hatsopoulos is the founder, president, and chairman of the board of Thermo Electron Corp (Waltham, MA). Thermo Electron is a collection of 14 high-tech companies that manufacture products as diverse as artificial heart pumps and explosives detectors, pollution-treatment systems and cogeneration power plants. Last year Thermo Electron had sales of more than $500 million and was number 472 on the Fortune 500 list. All of this evolved from an invention, created by Hatsopoulos in the early 1950s, that was a commercial failure.

The invention is the thermionic converter or thermo-electron engine. With no moving parts, this device converts heat directly into electricity. The converter operates very simply. A tungsten electrode is heated until electrons are emitted from its surface. The electrons move across a narrow gap and "condense" on a nickel collector. The flow of electrons creates an electric current. The process is aided by the introduction of low-pressure cesium vapor into the interelectrode space. The cesium vapor becomes ionized by the escaping electrons, which helps them move more freely.

Thermionic converters can run on any heat source—fossil fuel, solar, radioisotope, or nuclear reactor—that can provide temperatures greater than 1250° K. The energy conversion is independent of the size of the converter, so converters can be tailor-made for specific applications. Converters can also be manufactured in modules and linked together to provide whatever level of power is needed.

The problem with thermionic converters is that they are very expensive to build. They involve advanced technologies such as ultrapure fabrication and liquid-metal cooling. "Thermionic conversion works, which was greatly satisfying," says Hatsopoulos, who holds five patents dealing with energy conversion, "but by the same token it proved to be too expensive for commercial use. So it went into hibernation."

Other firms have gone out of business when the products they spent years developing proved to be duds, but not Thermo Electron. The expertise the company had gained in metallurgy was applied to making titanium hip-joint replacements. Its experiments in thermodynamics led to the manufacture of improved powerboat engines. And its fundamental research into how to produce electric power inexpensively and cleanly went into its designs for cogeneration plants.

The convoluted route from the thermionic converter to Thermo Electron's current array of products demonstrates how the creative process works within the company. Ideas are constantly recycled and recombined. New ones are added, and new ones are produced. One Wall Street analyst called Thermo Electron "a perpetual idea machine."

The man who keeps the idea machine primed is part engineer, part entrepreneur, and part politician. Hatsopoulos's thoughtful manner belies his abundant energy. In addition to running Thermo Electron, he researches and writes papers on economics, gives guest lectures at colleges, and confers often with high-ranking friends in the federal government. He keeps up a daunting pace, and at age 63 the only thing he is trying to cut down on is his cigar smoking.

Hatsopoulos was born in Athens, Greece in 1927 into a family of engineering professors and politicians. When the

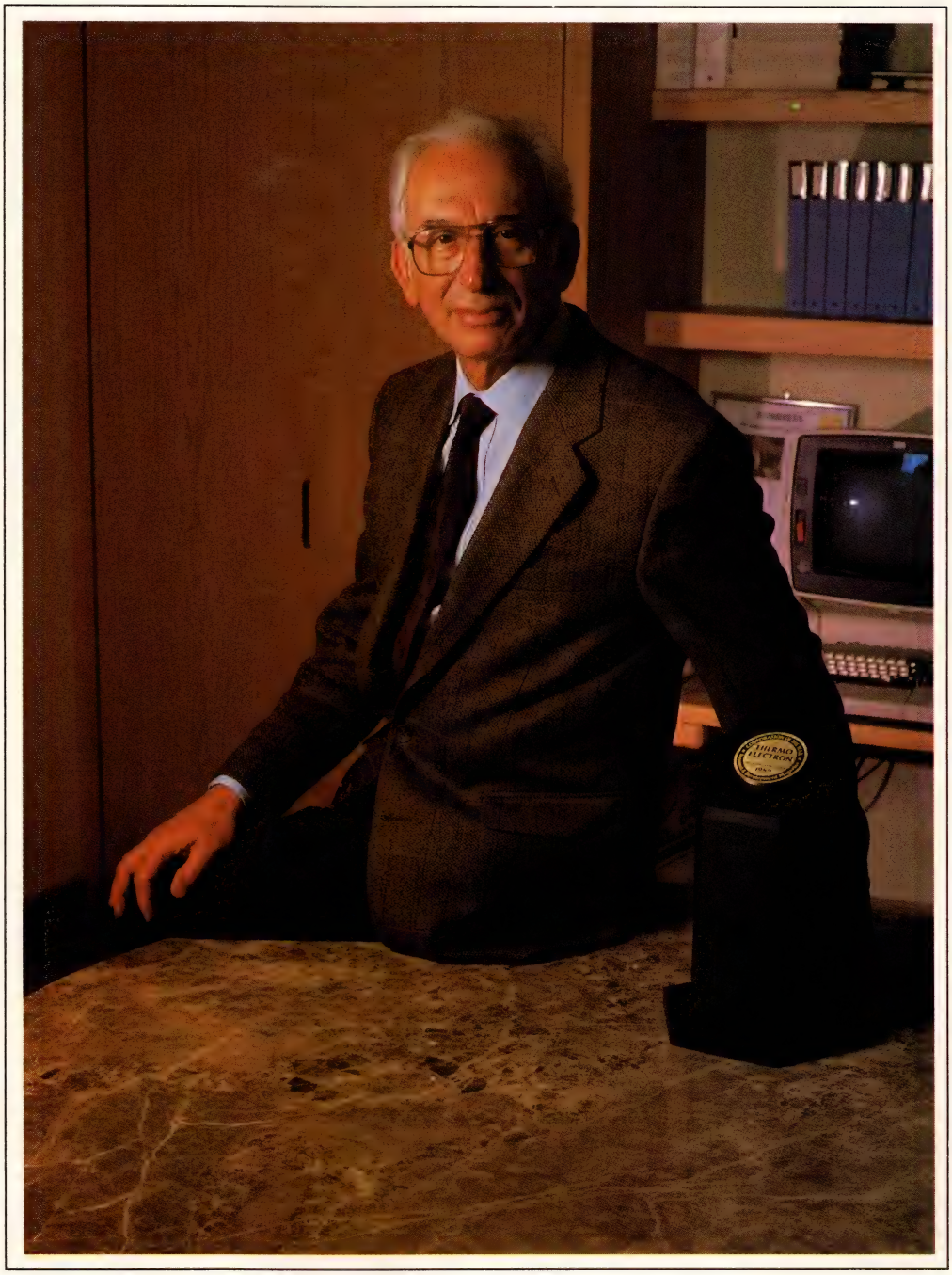
Germans occupied the country in 1940, he built radios in the basement of his house for the resistance movement. If he had been found out, he and his entire family would have been executed, so he kept his activities secret even from his own parents. Hatsopoulos says that after the war, when his father found out what had been going on, he almost had a heart attack.

In 1945 Hatsopoulos entered the National Technical University in Athens. He intended to study mechanical engineering and soon became intrigued by thermodynamics. He also began to see that Greece was too small an arena for his dream of building a ground-breaking high-tech company.

In 1948 Hatsopoulos won a scholarship to the Massachusetts Institute of Technology (Cambridge, MA). He earned his BS, MS, and PhD there and wrote his dissertation on thermionics. He also built a prototype of a thermionic converter. When it worked, he borrowed $50,000 and founded Thermo Electron in 1956, the same year he joined the MIT faculty.

Until 1962, Hatsopoulos taught engineering while he was steering Thermo Electron through its early, lean years. His persuasive skills enabled him to attract funding for the company's various research projects. For example, in the late 1960s Ford Motor Co backed an effort by Thermo Electron to produce a low-pollution automobile engine. "In developing it we encountered a difficulty. There were no instruments that we could purchase that would measure the emissions with the sensitivity we needed," says Hatsopoulos.

Then he and his engineers came across a process that could be used for measuring gases called chemiluminescence, which involved chemical reactions in a vacuum. "We had a lot of people who had developed expertise in chemical reactions in a vacuum because

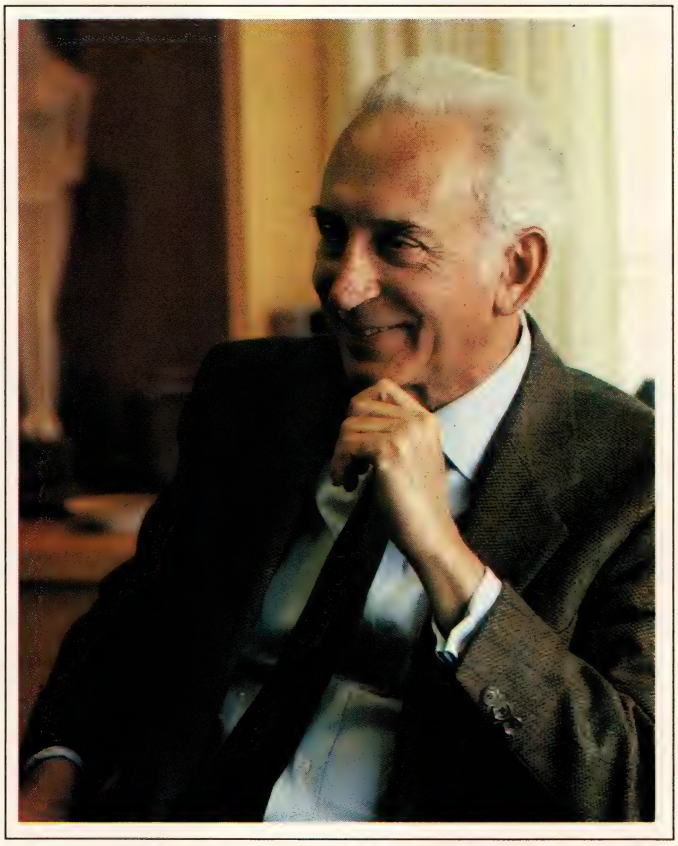


Photography by Kevin Bryan

George Hatsopoulos, president of Thermo Electron: "All I do is catalyze the process."

of our work in thermionic conversion," he adds. "Our engineers took over that process and made a breadboard instrument just for our own use. We had no thoughts of going into the instrument business."

In 1971 Congress passed the Clean Air Act. Suddenly, automakers had to have reliable instruments to measure emissions. Hatsopoulos decided to jump into this brand new market. He convinced Ford to order 12 instruments from him with a delivery time of three months.



"They were very reluctant to place an order with a company that had never made instruments," recalls Hatsopoulos, "but they had no choice because all the other instrument makers said they needed anywhere from 18 months to three years to produce something. So [Ford] had nothing to do but place the order, and if we hadn't delivered, of course, they wouldn't have paid us. But we did deliver—in three months."

That instrument was the foundation of Thermo Electron's most profitable subsidiary, Thermo Instrument Systems Inc. It has since branched out into instruments that detect and measure toxic substances, low-level radioactivity, and air pollutants.

Spinning off subsidiary companies is nothing new in the business world, but large firms usually spin off weak or unprofitable divisions and try to find buyers willing to take a chance on reviving them. Hatsopoulos has spun off his strongest divisions. By selling stock in them to the public (while always retaining the majority interest), he has been able to raise considerable amounts of money without resorting to bank loans.

Thermo Electron is also unusual in the large amount of freedom it gives to its subsidiaries. Hatsopoulos has tried to create a firm that combines the best of both worlds—the stability and financial resources of a large company with the energy and entrepreneurial spirit of a small company. To a large extent he has succeeded.

"In order to innovate you have to be prepared to fail," says Hatsopoulos. "I think that a lot of the problems in big companies come from the fact that they have lost the entrepreneurial spirit because people are too afraid of failure.

"We recognize that in order to advance technology you have to try things that many times don't work. We have probably been successful on average two out of three times, which is more than what I feel is satisfactory. But even if we were just successful one out of three times, it would be perfectly reasonable and justified."

"Reaching a goal can be satisfying...for a day."

Hatsopoulos has applied that same farsightedness to his commitment to research. In the early 1980s, when the high-tech industry was in a recession, many firms cut back on research and development to try to maintain their profit levels. Thermo Electron doubled its R&D budget, even though that meant its profits shrank to just $50,000 in 1983. But the investment paid off in the long run.

To keep the flow of new ideas coming into Thermo Electron, Hatsopoulos tries to recruit young engineers. "We find that the best source of entrepreneurial engineers is people just out of school with very little experience," he says. "We have the practice of bringing unusual people in without any specific jobs for them, hoping that within a few months we might be able to place them with new projects that require imagination and drive."

Hatsopoulos has the uncanny knack

for being the right man at the right time with the right technology. But it isn't a matter of luck. It's a matter of staying in touch with what's happening in the world. "Staying in touch is not just reading a headline or an article in a newspaper and always thinking how does this relate to our business," says Hatsopoulos. "It's also being a member of many business organizations and many nonprofit organizations that advise Congress and the administration, and seeing what they're thinking.

"That's only the first part of it. Then there's having discussions here in the company. We discuss what people feel are the coming problems. My standard questions this quarter will be, What do you think of the developments in eastern Europe? How will this make an impact on your business? Are you prepared for that impact?"

Hatsopoulos doesn't claim that he comes up with most of the ideas at Thermo Electron. "Usually they come from the divisions," he says. "My job, as it has developed in recent years, is to stir the pot, to keep people aware of what's going on around them and have them think of what they can do to take advantage of a changing environment. All I do is catalyze the process."

The process at Thermo Electron is illustrated by the evolution of the technology involved in the company's automobile-emissions monitor. The worst pollutants in auto exhaust are oxides of nitrogen, which the monitor was designed to detect. Combinations of nitrogen and oxygen also occur in a number of drugs prescribed for heart conditions, such as nitroglycerin. By applying the technology used in the auto-emissions monitor, the engineers at Thermo Electron developed an instrument to detect traces of certain drugs in samples of blood. The instrument was a success and led to the founding of another subsidiary company, Thermedics Inc.

Nitroglycerin is also an explosive, of course. It's the basic ingredient in dynamite. As dynamite and other explosives degenerate they give off fumes. Police forces and customs agents have long used dogs to sniff out hidden bombs. But dogs are not always reliable, and they're unable to find plastic explosives, which give off extremely faint fumes. Thermo Electron refined its emissions-monitor technology once again and came up with a portable "sniffer" so sensitive that it can detect nitrogen oxide in a concentration of only one part per trillion.

Heroin and cocaine also give off fumes containing nitrogen compounds. Another adjustment to the sniffer and it became capable of detecting these narcotics, too. Thermo Electron's sniffers are currently being tested at airports and US embassies.

Thermo Electron's basic concern has always been energy. Over the years the company has done many studies on energy efficiency, and Hatsopoulos's expertise in this field eventually drew him to Washington, DC. In 1976 he testified 17 times before various Congressional committees concerning energy legislation, and he was an advisor to President Jimmy Carter on his energy strategy.

"In order to innovate you have to be prepared to fail."

A passion for economics

Investigating energy costs has led Hatsopoulos to one of his current passions—the study of economics. He sees American business as endangered by the high cost of capital and the low level of personal savings by average citizens. He recommends that the federal government lower taxes on equity capital and issue high-yield bonds to encourage savings.

Hatsopoulos travels to Capitol Hill frequently to lobby for his proposals and to confer with powerful political figures such as White House Chief of Staff John Sununu (who was one of his students at MIT) and Budget Director Richard Darman. Closer to home, Hatsopoulos served as the Chairman of the Federal Reserve Bank of Boston in 1988 and 1989.

A shortage of investment capital won't be the only problem facing the US in the decade ahead, Hatsopoulos believes. Issues such as cleaning up the environment will persist and shortages of electric power will grow more severe.

"That's fairly certain because there

have been no new central power plants initiated in the last 10 years, and yet the demand for electricity is continuing to grow at about 3% per year," says Hatsopoulos. "It's very easy to see that in the mid-90s you're going to have brown-outs in many parts of the country, and you will have a major problem with electricity production."

Hatsopoulos believes cogeneration is a big step toward solving that problem. The cogenerators that Thermo Electron builds produce both electricity and heat from agricultural or lumber wastes. The energy is clean because the wastes are mixed with limestone before they're burned to absorb sulfur compounds. Combustion occurs at relatively low temperatures, reducing the production of nitrogen oxide. In addition, the exhaust is filtered to remove particulates. Thermo Electron has custom-engineered plants that put out up to 50 megawatts of power. Five of its cogenerators are already in operation and a sixth is nearing completion.

Hatsopoulos foresees continued growth for Thermo Electron through the 1990s. He has set a goal of turning it into a $1 billion company by the year 2000. "Reaching a goal can be satisfying . . . for a day," he says, "but you have to have a new goal again. Because the real goal is to create, and the more you create the more satisfied you are on a continuous basis. The goal is not really the fun part. The fun part is the process."

And what about the thermionic converter, the commercial failure that was the source of today's half-billion dollar company? It looks like the federal government may awaken it from its long slumber. Both NASA and the Defense Dept have become interested in the converter as a possible source of power for space vehicles.

"You can produce many megawatts with a nuclear reactor using a thermionic converter the size of a wastepaper basket. It's unbelievable how compact it can be," says Hatsopoulos. "When you need power in a concentrated form, as you would for interplanetary travel, I don't think there's anything that comes close to thermionic conversion. We'll see that in the 21st century." EDN

Article Interest Quotient (Circle One)
High 488 Medium 489 Low 490

"My job is to keep people aware of what's going on and have them think."

READY FOR A CAREER CHANGE?

EDN Magazine needs an engineer who will work with us as a technical Regional Editor. This job entails reporting and writing about semiconductor and integrated-circuit developments from the San Jose, CA area. In this position, you'll be based in Silicon Valley and will primarily cover the important technologies and products developed at local companies. However, from time to time you'll travel outside Silicon Valley to attend meetings, conferences, and industry shows. As an EDN Regional Editor, you'll write about individual products, write feature-length technical articles, and scout for contributed articles. Also, you will get to meet and know the top people in today's important electronics companies. The right person for EDN will have at least a BSEE and two years of hands-on design experience using digital or analog ICs and the ability to write and speak well. Past experience writing application notes, technical articles, or other articles is a plus. Our salary is competitive with that in an equivalent engineering position.

Cahners Publishing Company offers competitive salaries and benefits including medical/HMO and dental coverage (pre-tax deduction), company-paid life, accident, and disability insurance, 401K salary-investment plan, pension plan, 100% tuition reimbursement, and a comprehensive relocation package.

Interested applicants should send their resume and salary requirements to Ms. Kathy Leonard, EDN Magazine, 275 Washington St., Newton, MA 02158.

EDN Magazine Edition News Edition **An Equal Opportunity Employer M/F/V/H**

EDN PRODUCT MART

This advertising is for new and current products.

Please circle Reader Service number for additional information from manufacturers.

DS-51 CEIBO



8051 EMULATOR $950*

INCLUDED IN THE PURCHASE PRICE

- Real-time and transparent In-Circuit Emulator with 64K breakpoints, 64 KByte Internal Data and 64 KByte Internal Code Memory.
- Personality probe for ROMless versions of 8051 µC (8031-2 - etc).
- User software including symbolic debugger, on line assembler and disassembler, PLM and C support, source and listing windows.
- RS-232 Interface Cable and Power Cord.
- User's Manual and Operating Instructions.

AND OF COURSE THE GREAT OPTIONS !!!

- Trace and Logic Analyzer-32K x 32 - 5 External Testpoints $800*
- EPROM Programmer for 27xxx type memories $250*
- Personality Probe for 8051 µC with Internal Code $500*

For more information call or write to:

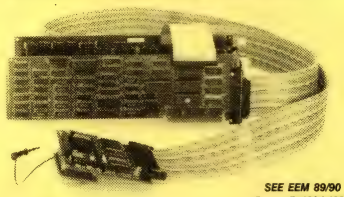
USA:	105 Gleason Rd. Lexington MA 02173	Phone	617-863-9927
		Fax	617-863-9649
Germany:	Krankenhausstr. 12 D-8870 Günzburg	Phone	(082-21) 30023
		Fax	(082-21) 30462
Hong Kong:	P.O.Box 30719 Causeway Bay	Phone	(852) 5-454341
		Fax	(852) 5-8541302
Israel:	P.O.Box 2106 Herzelyia 46120	Phone	(972-52) 555387
		Fax	(972-52) 559170

*US ONLY

CIRCLE NO 325

68HC11

PC-based emulator for 68HC11



SEE EEM 89/90 Pages D 1324-1326

- PC plug-in or RS-232 box.
- Pull-down menus with full window support, combined with command-driven User Interface.
- Up to 33 MHz (E clock) real time emulation.
- No intrusions to the 68HC11's resources.
- 48 bit wide 16K deep trace. All functions usable without disturbing emulation. Time stamping. Two level trigger.
- Symbolic and C Source Level Debugging, including in-line assembler and disassembler.
- Supports A, E, D and F parts.

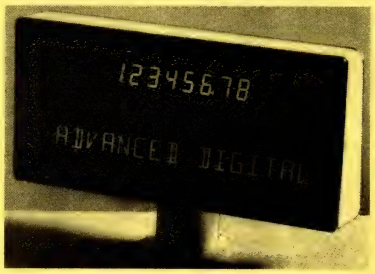
Prices: 64K Emulator and pod $2590;* 4K Trace $1995*

CALL OR WRITE FOR FREE DEMO DISK!

nohau CORPORATION
51 E. Campbell Avenue
Campbell, CA 95008
FAX (408) 378-7869
(408) 866-1820
*US only

CIRCLE NO 326

GENERAL PURPOSE DISPLAY UNITS



Stand-alone display units which come in 6 different sizes including 2 lines by 16 and 2 lines by 20 characters. These units communicate on RS232C lines with selectable speed. Green bright display, suitable for PC based POS systems, computers, security systems, industrial controllers etc. Low cost units with scroll, line blink and messages storing capabilities. Units with pass through features and parallel I/F also available. They can also be factory programmed for special applications. It can be mounted on top of a housing, table top, or on a pole.

Advanced Digital Machines Ltd.
550 Parkside Drive, Waterloo, Ont. N2L 5V4
Canada

TEL./FAX (519) 888-6811

CIRCLE NO 327

Don't Get Zapped!

High inrush current can **destroy** your sensitive VAX CPUs and peripherals **in less time than it takes to flip a switch.**

THE SOLUTION?
Power up with ***Z-LINE* TPC 115-10 MTD™ the smallest** power distribution and control system available.
POWER UP WITH — — — Z-LINE



Our proprietary **Multiple Time Delay™ circuitry sequences** your power-up to **protect** your systems from the spikes and surges, EMI & RFI, that **destroy your hardware and erase your data.** And our remote on/off and emergency shutdown **gives the power control back to you.**

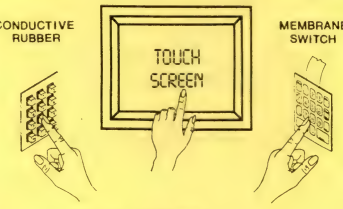
All Pulizzi Engineering MTD™ **controllers are compatible with DEC and UPS systems.**
PRICES FROM $453 TO $317

DON'T WAIT UNTIL IT HAPPENS, CALL TODAY!
PULIZZI ENGINEERING INC.
3260 S. Susan Street, Santa Ana, CA 92704-6865
(714) 540-4229 FAX (714) 641-9062

CIRCLE NO 328

KEYTEC, INC.

WHERE YOU SHOULD GET IN **TOUCH** WITH



- ANALOG OR MATRIX
- STANDARD OR CUSTOM
- RS-232 OR PC BUS CONTROLLER
- COMPONENT OR INTEGRATED MONITOR
- CUSTOM CONTROL PANEL WITH COMBINATIONS OF:
  1. GRAPHIC OVERLAY
  2. TOUCH SCREEN
  3. SILICON RUBBER
  4. METAL OR PLASTIC PANEL
  5. MEMBRANE SWITCH
  6. LCD, LED

1401-2 CAPITAL AVE., PLANO, TX 75074
TEL: 214-424-3459 FAX: 214-423-3049 OR 214-530-8510

CIRCLE NO 329

Still having circuit simulation problems???

- Spice Simulator Training
  Beginner's Class
  User's Class
  Expert's Class
  Programmer's Class
  On-Site or at our facility
  Cost per class: $240 /stu.
- Inside Spice
  The newsletter for circuit simulation users
  Regular Columns: *Users' s Corner*, *Spice Tips*, *Models and Macros*
  Published 6 times/yr
  Cost: $60.00 U.S.
- Technical Consulting
  Problem solving for circuit simulation
  Custom simulation ports, *Pre- and Post Processors*, *Model Installation*, *Statistical Model Control*

RCG Research, Inc. 800-442-8272
Innovative Ideas in Electronic Design

CIRCLE NO 330

To advertise in Product Mart, call Joanne Dorian, 212/463-6415

There is a Difference.

Lifetime Free Updates



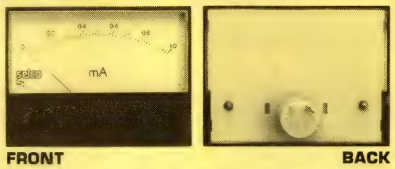
EP-1140
$895

A programmer is not just another programmer. That is why BP Microsystems is commited to bringing our customers the highest quality programmers at an affordable price. This commitment is evident in our EP-1140 E/EPROM programmer supporting thousands of 24-, 28-, 32- and 40 pin devices. A 32-pin model, EP-1132, is available also for $695. And, all of our programmers include future chip support at no charge and an unconditional money back guarantee.

BP MICROSYSTEMS
1-800-225-2102
(713) 461-9430

CIRCLE NO 331

DREAM METER



FRONT BACK

80% SMALLER MOVEMENT, 66% FEWER PARTS.

Core magnet design ▪ Dramatically reduced total volume ▪ Taut band suspension ▪ Accuracy to ±1.5% of full scale ▪ Four sizes ▪ AC and DC versions ▪ Standards conformance ▪ Custom Marking Services

selco PRODUCTS CO.
7580 Stage Road, Buena Park, CA 90621
(213) 921-0621 ▪ (800) 229-2332
FAX (714) 739-1507

CIRCLE NO 332

CAD Showdown Results!!

HIGH DENSITY EXPERTS!

Schematic Capture ♦ PCB Layout♦ Autorouting

Top-rated DC/CAD out-routed the competition in the 1990 CAD Showdown. Routing the challenging benchmark on a double-sided board while competing routers used four to six layers, DC/CAD displayed the power and flexibility needed in a top-notch design package to tackle high density board jobs. This non-copy protected package with surface mount support includes:

- High capacity schematic capture
- Multi-strategy 1-mil parts autoplacer
- "1-mil" autorouting w/ripup & retry
- Thorough annotating design rule checker
- Full 2-way GERBER and DXF support
- Optional autoground plane support with cross-hatching
- Optional protected-mode version for 386 Users and much more!

CALL TODAY. Priced at $495.



DESIGN COMPUTATION
Rt. 33, Sherman Square Farmingdale, NJ 07727
(201) 938-6661 ♦ (201) 938-6662 (FAX)
Smart Software for Tough Board Design.

CIRCLE NO 333

FREE Catalog of Books for Engineering Professionals

These books will help you work smarter, faster, and better.

Topics include: surface mount technology, DRAM design, ISDN design, AC power conditioners, software, hardware, busses, integrated circuits, error-control, power switching supplies, voltage regulators, ASICs, and more—all written with an eye to *practical* applications!

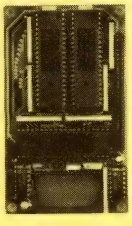
Call 1-619-699-6400 or write for your free catalog TODAY!

Academic Press
Harcourt Brace Jovanovich, Publishers
Book Marketing Dept. #24060
1250 Sixth Ave., San Diego, CA 92101

©1990 by Academic Press, Inc. All Rights Reserved. KL/MJD #24060

CIRCLE NO 334

PC KEYBOARD INTERFACING



ENCODER
The "Smart-Wye"
Allows switches and keypads to drive PC keyboard input.



ELIMINATOR
The "Phantom Keyboard"
Allows PC boot-up and operation without keyboard.

VETRA SYSTEMS CORPORATION
1670 Old Country Rd., Plainview, NY 11803 • Tel (516) 454-6469 FAX (516) 454-1648
Smart-Wye and Phantom Keyboard are trademarks of Vetra Systems Corp.

CIRCLE NO 335

Disk Drive / Tape Power Supplies



Low Cost / Affordable Power Supplies for Disk, Tape and Optical Drives. Compact, proven reliability with agency approval.

Introductory Offer - ONLY $21.95*

Please Call
Lien Engineering, Inc.
(619) 695-1070
7940 Arjons Dr.
San Diego, CA 92126

*OEM Quantity Price

CIRCLE NO 336

Wave Form 20MHz - 32K $1290

The WSB-100 Wave Form Synthesizer Board from Quatech has the best set of numbers in the market. With speed to 20MHz and a 32K memory at $1290, it's making waves in more ways than one. The WSB-100 is also a star performer as a digital pulse/word generator with the optional digital module.

Call for our free PC Interface Handbook
1-800-553-1170

QUATECH
666 Wolf Ledges Parkway
Akron, OH 44311

CIRCLE NO 337

CIRCUIT SEARCH

Electronics Designers, Engineers, Educators, Researchers:
Bibliographic Database of sources (papers/articles from journals/magazines) for over 10,000 practical electronic circuits. Why wait online on an expensive database service when you can have it on your PC?

- user-friendly menu-driven search
- search for articles by keywords in titles, circuit descriptions, device types, etc. (Boolean searches too)
- interdisciplinary – references over 250 journals (electronics, physics, chemistry, computers, agriculture, many more)
- applications in analog, digital, computers, interfacing and RF
- data in standard dBase ® III compatible .DBF files
- subscription to update and revision services available
- photocopies of most by FAX or mail (copyrights honored)
- Package: $375US / Sample: $7.00 (to cover costs)

FAX (519) 742-4594 Phone (519) 745-7830
P.O. Box 268, Breslau, Ontario, Canada N0B 1M0

CIRCLE NO 338

ELECTRONIC DESIGN SERVICES

- Initial concept through prototype and production
- Design of advanced digital and analog electronics
- Approved programmable gate array design center
- Real - time embedded software - DSP code
- 7,000 square foot facility with fully equipped labs
- 12 year track record of successful product designs
- Designs are warranted Defect Free Forever

PRESCO (203) 397-8722

CIRCLE NO 339

To advertise in Product Mart, call Joanne Dorian, 212/463-6415



MICRO/Q 2000

FOR A DECOUPLING CAPACITOR THAT SAVES SPACE, DEFEATS NOISE, IS SUITABLE FOR MILITARY APPLICATIONS AND BEATS HUMIDITY, HEAT AND COLD:
ROGERS MICRO/Q® 2000
Rogers Corp., 2400 S. Roosevelt,
Tempe, AZ 85282, 602/967-0624

CIRCLE NO 340

... NEW... NEW... NEW... NEW... NEW... NEW...

Powerful FORMAT CONVERSION Tool

Reads in	Writes out
GERBER™	GERBER™
HPGL™	HPGL™
DXF™	HPGL II™
DMPL™	DMPL™
EXCELLON™	EXCELLON™
	POSTSCRIPT™
	APPLE LaserWriter™
	HPS (QUICK DRAFT)

VPLOT II™

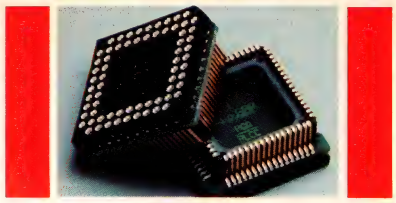
VIEW YOUR FILES & PRINT THEM ON LASER PRINTERS

VPLOT II format conversion tool : $350
VPLOT II + VIEW & PRINT : $495
30 DAY MONEY BACK GUARANTEE

ALS DESIGN

CALL TODAY (617) 621-7101
ALS DESIGN CORPORATION
One Kendall Square, # 2200
Cambridge, MA 02139

CIRCLE NO 341



PLCC ADAPTORS/EMULATORS

- Adapts from 44, 52, 68, or 84 pin PLCC socket to stamdard .100" (2.54mm) grid male/female PGA pattern
- Fits securely in most manufacturers' PLCC sockets
  Custom patterns and pins available

For Adaptor Data Sheets or FREE Full Line Catalog
Call (415) 651-2700 or Fax (415) 651-1020

Service and Engineered Solutions . . .

MCKENZIE TECHNOLOGY

44370 Old Warm Springs Blvd. Fremont, CA 94538 USA

CIRCLE NO 342

TOP GUN 90'

AutoPCB Wins CAD Showdown Contest

(13 CAD vendors participated)

- Highest Router Completion Rate
- Shortest Board Design Time
- Best SMT AutoRouter
- Best Board Manufacturability
- Best Overall PCB Design Package

Get your free copy of the CAD Showdown result from **CADISYS**
2099 Gateway Place, Suite 400, San Jose, CA 95110
(408) 441-8800 FAX (408) 441-8300

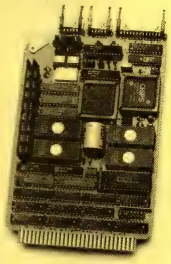
CIRCLE NO 343

CMOS 186 SINGLE BOARD COMPUTER

MULTI-TASKING

This powerful 16-bit computer directly executes EPROM's containing Microsoft C or Turbo C .EXE files. NO LOCATORS! Bundled package including multi-tasking C library allows dozens of C tasks to run concurrently.

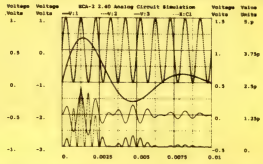
- *10 MHz 80C186*
- *CMOS design*
- *512K RAM*
- *384K EPROM*
- *STD BUS Expansion*
- *COM1 RS232/485*
- *COM2, LPT1*
- *RTC Avail*
- *80C187 Avail*
- *OEM discounts*



MICRO/SYS
1011 Grand Central Ave., Glendale, CA 91201
(818) 244-4600 Fax (818) 244-4246

CIRCLE NO 344

Interactive/Real-Time



Analog Circuit Simulation

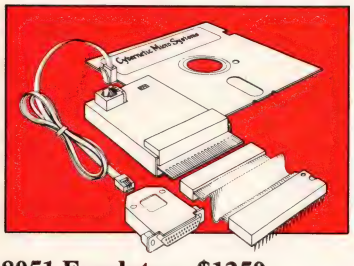
ECA-2 Electronic Circuit Analysis offers the best MonteCarlo and Worst-Case analyses with the capability to concurrently plot random samples or Min/Max/Nominal values.

• AC, DC, Transient, Fourier, and Temperature Analysis • Interactive or batch modes • Full nonlinear simulator • Sine, Pulse, PWL, SFFM, and Exponential generators • IBM PC/Mac/SUN • Multiple plots • On-line real time graphics – **2 to 50 times faster than SPICE** • Over 500 nodes • Advanced component parameters • Component Sweeping • Full editing, built-in or external • Detailed 525 page manual

Call for FREE DEMO!

Tatum Labs, Inc.
3917 Research Park Dr. B-1, Ann Arbor, MI 48108
313-663-8810

CIRCLE NO 345



8051 Emulator - $1250

d²ICE is a low cost, Full Speed, real time 8051 Emulator.. Powerful user interface for Hi-level multi-window source code debugging. Uses IBM-PC COM1/2. No Slots! Portable, fits in shirt pocket. Assembler and test bed included.

Cybernetic Micro Systems
PO Box 3000 • San Gregorio CA 94074
Ph: (415) 726-3000 • Fax: (415) 726-3003

CIRCLE NO 346

IVEX Integrated Circuits For Image Processing

PWA-01 Partial Weighted Averager

The PWA-01 consists of 2 9×9. two's complement multipliers and a 3 input adder which can be used at video rates, to perform real-time interpolation, on pixel video data.

- 84 Pin PLCC Packaging
- Low Power CMOS Construction
- Separate Clocks for Holding Static Weighting Factors
- 24 Mhz. Operation
- 3-State Outputs
- 9 Bit Input Data
- Supports Signed and Unsigned 8 Bit Integer and Fractional Number Types
- Full Bandwidth on All Data Paths
- 16 Bit Results with Rounding for 8 Bit Integer Portion
- High Performance Arithmetic Processing of Video Data Streams

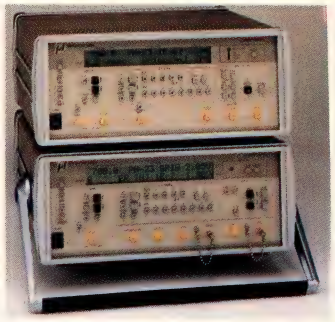
RXC-01 Address Generator

The RXC-01 is an auto-sequencing, 32 bit address generator designed primarily for resampling a two-dimensional image, to produce a transformed output image.

- 84 Pin PLCC Packaging
- Low Power CMOS Construction
- Up to 19 Mhz. Operation
- 32 Bit Operation
- 16 Bit Microprocessor Interface
- Built in Support for Floating Point Conversion of Output
- Programmable Scaling of Output
- Image Transformations

For more information, please contact:
Sam Burroughs, 4355 International Blvd., Norcross, GA 30093
(404) 564-1148 Fax: (404) 381-0622

CIRCLE NO 347



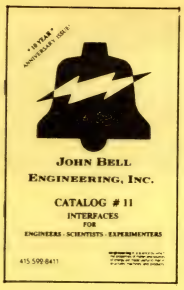
gigaBERTS HIGH SPEED DIGITAL TESTERS

- Bit Error Rate Testing to 700 Mb/s
- Internal 1 to 700 MHz PLL Clock Source
- Pseudo-Random and Fixed Patter Word
- WORD Option of 32 Kbits for SONET & FDDI
- Error Injection
- Amplitude and Offset Control
- Auto Search Synchronization

Microwave Logic
20 Cummings Rd
Tyngsboro, MA 01879
Tel: (508) 649-6099
Fax: (508) 649-4722

CIRCLE NO 348

To advertise in Product Mart, call Joanne Dorian, 212/463-6415



Free Catalog of DIGITAL I/O and ANALOG Input Interfaces for the IBM-PC,XT,AT and compatibles. Control relays, motors, lights, measure temperature and voltage. Sample programs and I/O circuits are included in catalog. John Bell Engineering, Inc. 400 Oxford Way, Belmont, CA 94002

(415) 592-8411

CIRCLE NO 349

Want to try this with your LCD display?

Call Planar to see the EL solution.

503/690-1100

PLANAR



CIRCLE NO 350

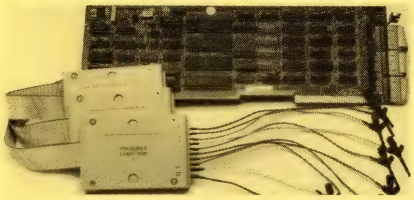


smARTWORK® PCB Software. In a fraction of the time hand taping requires, you can create double-sided printed-circuit boards with smARTWORK and your IBM PC. The program's features include continual design-rule checking, automatic pad shaving, a silkscreen, and text for all three layers. **smARTWORK** with autorouting is $895 (without, $495) and comes with a 30-day money-back guarantee. Credit cards accepted. Write or call

Wintek Corporation
1801 South Street, Lafayette, IN 47904
(800) 742-6809 or (317) 742-8428

CIRCLE NO 751

200 MHz LOGIC ANALYZER



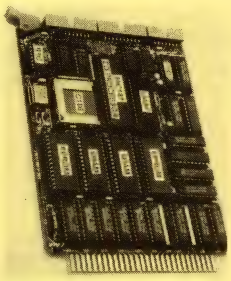
- 200 or 100 MHz max sampling rate (6 channel)
- 24 Channels (50 MHz), Timing and State
- Optional expansion to 72 channels
- 16 Levels of triggering
- 16K samples/channel (6 channel mode)
- Variable, TTL, or ECL threshold levels
- 3 External Clocks and 11 Qualify lines
- FREE software updates on 24 Hour BBS

$1299 - LA27100 (100 MHz)
$1899 - LA27200 (200 MHz)

Price is complete Pods and Software included

POWERFUL • AFFORDABLE TEST INSTRUMENTS

CIRCLE NO 752



16 MHz 80C186 / C187
SINGLE BOARD COMPUTER

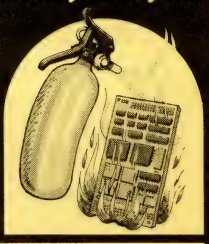
R.L.C. continues to offer the latest technology on the STD Bus. Our newest 16-bit Single Board Computer offers a CMOS 80C186 and new CMOS 80C187 Numeric Co-Processor. On-Board functions include MEMORY, SERIAL PORT, REAL TIME CLOCK, TIMERS, DMA, INTERRUPT CONTROLLER, RTC and RAM BATTERY BACKUP, WATCH-DOG TIMER and much more. Available in speeds up to 16 MHz. For more information and technical assistance please call Robert Coomer at

R.L.C. ENTERPRISES
4800 Templeton Road, Atascadero, CA 93422
(805) 466-9717

CIRCLE NO 753

Thermal- Reliability Analysis

BETAsoft-R gives you



- Mean Time Between Failure of Boards
- Failure Rate of each component
- MIL-HDBK-217E Compatible
- Interface to P-Cad, PADS-PCB, Auto-CAD, and Racal etc.
- 3-D Thermal Modelings for SMT boards
- Menu-driven, 2,500 component library
- 2.5 min on IBM/AT per 100 components

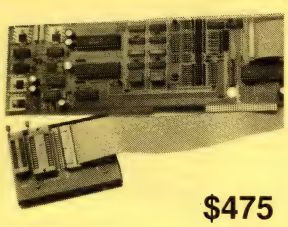
BETAsoft-R $2,995
Free Demo. Dynamic Soft Analysis, Inc.
Tel. 412-781-3016 Fax 412-781-3098

CIRCLE NO 754

Almost Universal Device

PROGRAMMER

PAL
GAL
EPROM
EEPROM
PROM
87xxx...



$475

LATTICE - MMI - INTEL - TI
AMD - DALLAS - ALTERA

5ns PALs
2 Meg EPROMs

Parts added at your request.

FREE software updates on BBS.
Powerful menu driven software.

CATALYST - XICOR
WSI - ICT - and MORE

Call - (201) 994-6669

Link Computer Graphics, Inc.
4 Sparrow Dr., Livingston, NJ 07039 FAX:994-0730

CIRCLE NO 755

BIOS SOURCE CODE

The AT BiosKit gives you a complete Bios with source code in C you can modify for your own applications! The BiosKit includes a Bios on diskette ready for programming Eproms, and includes the utilities you need to Rom the source code. The Bios also has a Rom Monitor/Debug and Setup. At last you have control over the core of your system. Over 380 pages, with diskette, $199. The XT BiosKit is only $99. The Intel Wildcard Supplement for the XT BiosKit is $49. Software tools: You need MS C and MASM 5.1 for modifying the Bios.

FREE We'll include a free copy of the pocket-sized **XT-AT Handbook by Choisser and Foster** with each BiosKit if you mention this ad when you order. Of course, this $9.95 value is also available by itself. Or buy five or more for only $5.00 each.

VISA **800-462-1042** MasterCard
In California 619-271-9526

Annabooks
12145 Alta Carmel Ct., Suite 250
San Diego, CA 92128 **Money-back guarantee**

CIRCLE NO 756

RELIABILITY PREDICTION SOFTWARE

ARE YOUR PRODUCTS RELIABLE?

The RelCalc 2 Software Package predicts the reliability of your system using the part stress procedure of MIL-HDBK-217E, and runs on the IBM PC and full compatibles. Say goodbye to tedious, time consuming, and error prone manual methods! RelCalc 2 is very easy to use, and features menu windows, library functions, global editing for what-if? trials, and clear report formats. Try our Demo Package for $25.

T-CUBED SYSTEMS, 31220 La Baya Drive #110, Westlake Village, CA 91362. (818) 991-0057 • FAX: (818) 991-1281

CIRCLE NO 757

To advertise in Product Mart, call Joanne Dorian, 212/463-6415

PLASMADOT: Dot matrix for graphics as well as text!

Cherry announces PLASMADOT,™ a bright new dot matrix gas plasma display. Designed for high-volume OEM applications ranging from management equipment to information centers. High-brightness pixels and contrast; round, square or rectangular pixel shapes. Full-field dot matrix display ideal for graphics as well as text. Write or call Cherry for details today!

CHERRY

The Cherry Corporation
Cherry Electrical Products
3600 Sunset Avenue, Waukegan, IL 60087
Phone: 708/360-3500 • Facsimile: 708/360-3566

CIRCLE NO 758

REENTRANT MATH LIBRARY
for Microsoft C

PACLIB 3.0 is a drop-in replacement for Microsoft C's Alternate Math Library. PACLIB is reentrant, fully ROMable and supports all memory models. And, its smaller and faster than Microsoft C's Alternate Math Library.

For more information about PACLIB, and our full line of numeric software products, please call or write to:

U S SOFTWARE

United States Software Corporation
14215 NW Science Park Drive
Portland, Oregon 97229
(503) 641-8446 / 800-356-7097

Microsoft C is the trademark of Microsoft Corporation.

CIRCLE NO 759

LEMO QUALITY CONNECTORS



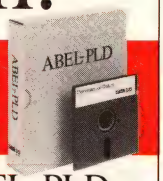
Self-latching, circular, quick connect-disconnect connectors are available in multi or mixed contact configurations, high voltage, environmentally sealed, fiber optic, fluidic, coaxial, triaxial, thermocouple and plastic.

LEMO USA, INC.
P.O. Box 11488
Santa Rosa, CA 95406
Phone (800) 444-LEMO
FAX 707/578-0869.

CIRCLE NO 760

Design:

Industry-standard language for PLDs



With new ABEL-PLD at just $895*.

- 150 PLD architectures supported (over 4000 devices).
- Uses ABEL™ Hardware Description Language (AHDL).
- Intelligent synthesis and optimization.
- Upgradable to full-featured ABEL.

Call for your **FREE** ABEL-PLD demonstration diskette.
1-800-247-5700

*U.S. list price only.

DATA I/O Corporation

CIRCLE NO 761

Program:

16L8, 20V8, 22V10, 27C020, and 450 other CMOS devices



PLDs and memories with the low-cost 212.

- Memory cards for easy updates.
- Extensive editing capabilities.
- Compatible with JEDEC standard programming files.

Call for your **FREE** 15-day trial AND ABEL-PLD demonstration diskette.
1-800-247-5700

DATA I/O Corporation

CIRCLE NO 762

TRANSMISSION-LINE PROBLEMS?



Interactive Transmission-Line Simulator

Designing digital systems? With today's fast edges, chances are good you've got transmission-line problems.

LineSim is a new tool just for transmission-line design.

It features:
- a push-button schematic
- two PCB-impedance calculators
- models for major device families
- an oscilloscope display
- a totally interactive environment

LineSim shows you your signals when it makes the most sense: *before* you build boards. And it'll *teach* you more about how transmission lines work than a whole pile of dusty books.

30-day money-back guarantee. $595 Requires IBM PC with EGA.

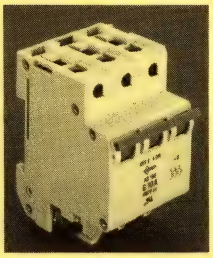
HyperLynx

P.O. Box 3578 Redmond, WA 98073-3578 (206) 869-2320

CIRCLE NO 763

WEBER

AS 168 Energy Limiting Circuit Breaker



- Superior Short Circuit Protection
- Selective Disconnection – No nuisance shutdown
- Easy Installation with Quick Connect Terminals, screw terminals, or DIN Rail Mounting
- Worldwide Approvals, VDE, UL, & CSA
- Single, Double, Triple, and four pole versions
- Current Ratings – 0.5 to 50 Amp
- AC rating to 480 and DC rating 120 Volts per pole
- Available with Switched Neutral, Auxiliary and Signal contacts
- Stock available in Connecticut

Contact: **Inmark Corporation**, 4 Byington Place
Norwalk, CT 06850 Telephone: 203-866-8474
Fax: 203-866-0918

CIRCLE NO 764



RS232 EE/EPROM, MICRO & MEMORY CARD PROGRAMMER $345/495

- Programs **EE/EProms, Flash Eproms, ZPRams, Intel Micros, Memory Cards.**
- **Stand-Alone Mode** for EE/EProms and Memory Card Duplication / Verify.
- All 24/28/32 pin EE/EProms to **8 MBits** (upgradeable to **32 Megabits**). Micros:8741/A,-2/A,-4,-8,-9,-51,-C51,-C51FA/B,-52,-53,-55,-C521,-C541,9761.
- Accepts dedicated modules: **Memory Card Programming Module** (Seiko, Fujitsu) - $145, **Eraser/Timer Module** - $50, **Gang Module** (4 sockets) - $145. Simultaneously duplicates up to 5 devices in stand-alone mode (with Gang).
- Can be operated with any computer containing an **RS-232 serial port.**
- **User friendly Menu-Driven Interface Program for IBM-PC** or **Macintosh.**
- **Full 1 year warranty.** Customer support via voice line, fax or **dedicated BBS.**

INTELLIGENT ROM EMULATOR $395

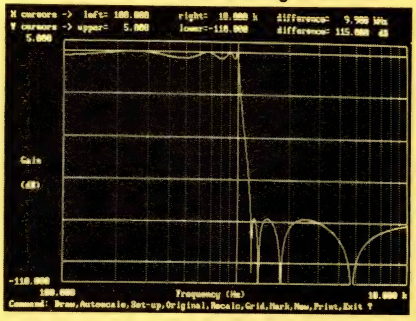
- Emulates **2716** through **27512** EProms with a single unit. **Access time 120ns.**
- Connects to the **standard parallel printer port** via a standard printer cable.
- User friendly software. Command set includes: **Load**(data), **Write**(data), **Display**(memory), **Type**(of EProm), **Edit**(memory), **Fill**(memory), **Calculator**, **Reset**(target system), **Activate**(debugging feature), **Monitor**(selected feature).
- **Address Compare with Halt output, Address Snapshot, Trigger input.**
- **Fast data loading via parallel printer port (64k bytes in less than 10 sec).**
- **Cascadable up to 8 units.** Includes target cable with Trigger/Reset/Halt clips.
- CMOS (stand-alone) model with rechargeable NiCad battery backup: **$495**

MC / VISA / AMEX *Call today for datasheets!*

B&C MICROSYSTEMS INC.
355 West Olive Ave, Sunnyvale, CA 94086 USA
TEL:(408)730-5511 FAX: (408)730-5521

CIRCLE NO 765

New AFDPLUS
Advanced Active Filter Design Software



- Fully Interactive
- On Screen Design & Evaluation
- On Screen Editing
- Menu Driven
- Automated Installation
- Schematic Display & Print
- Integrated AFDSIM

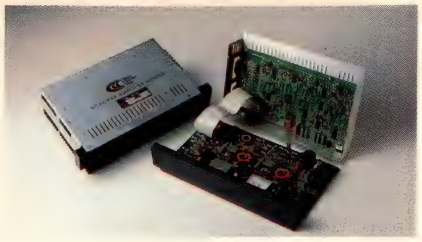
Introductory price $850.00 (price effective through 01/31/90)
Call for your **FREE DEMO DISK** (303)-499-7566 or to order AFDPLUS send check or purchase order to

RLM Research
P.O. Box 3630
Boulder CO 80307-3630

MasterCard® VISA®

CIRCLE NO 766

To advertise in Product Mart, call Joanne Dorian, 212/463-6415



High Power 71kHz Power Amplifiers (Master/Slave System)

Model 220/230

- Highest freq. 71kHz
- Lowest noise...pure DC output
- Performs like a linear amplifier
- Master/slave design...power from 1kW to 30kW at 150 volts
- DC output eliminates RFI

Copley Controls Corp.
375 Elliot Street
Newton, MA 02164
Tel: 617-965-2410
FAX: 617-965-7315

CIRCLE NO 767

WORLD FIRST
FOR DESIGNERS OF ANALOG AND DIGITAL EQUIPMENT FOR ELECTRONIC IMAGING, TV, etc.

LOW PASS **VIDEO FILTER CATALOG**
ON IBM COMPATIBLE COMPUTER DISC
HIGH DENSITY 5 ¼"

Matthey | CUT OFF FREQUENCY MHz

FREE

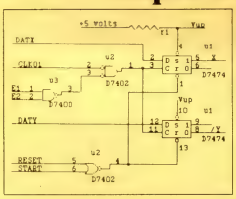
YOU CHOOSE AND ENTER THE CUT OFF FREQUENCY BETWEEN 0.02MHz AND 30MHz

- A Filter Design Consultant On Your Own Computer
- Fully Interactive
- You Change Cut Off Frequency
  New Spec Instantly Provided
  And Dimensioned Drawing
- Phase Equalised Filters
  (For Electronic Picture Equipment)

TELEVISION EQUIPMENT ASSOCIATES INC
914-763-8893

CIRCLE NO 768

SuperTOOL™



Schematic Entry, Printed Circuit Board Software for the IBM PC & Compatibles *only* $299.00

COMPLETE PACKAGE

- Automatic Operation from schematics to printed circuit board art work
- Create double-sided boards up to 6" X 13" with plated-through holes
- Software includes schematic editor with netlister, autorouter and printed circuit-board editor (buy separately at $99.00 each)
- Fully documented with manuals and on-line help
- Extensive digital, analog and discreet part libraries
- Includes netlist conversion utility disk ($49.00 value)

Write or call for further information:

MENTAL AUTOMATION, INC.

ORDERS/INFORMATION:
Send check or money orders to:
Mental Automation, Inc., Dept.S-9,5415 136th Place S.E., Bellevue, WA 98006 or call (206) 641-2141
Visa/MasterCard orders accepted!
Dealer inquiries welcomed.

CIRCLE NO 769

FREE CAD/CAE SOFTWARE CATALOG

GRAPHICS TRANSLATORS • SYMBOL LIBRARIES
THERMAL ANALYSIS • DESIGN RULE CHECKING
PARTLIST GENERATORS • NETLIST CHECKING
NETLIST TRANSLATORS • RELIABILITY ANALYSIS
PCB LAYOUT • ECO TRACKING • LIBRARY MANAGMENT • SCHEMATIC CAPTURE • TEST GENERATORS • AND MUCH MORE

SUPPORTED SYSTEMS INCLUDE:
ORCAD • P-CAD • FUTURENET • AUTOCAD
OMATION SCHEMA • TANGO-PCB • CALAY
PADS-PCB • HEWLETT PACKARD • CADNETIX
REDAC • GERBER • EE DESIGNER • TELESIS

Send for your free catalog of quality add-on software today!

CAD UTILITY COMPANY
21115 Devonshire Street, Suite 318
Chatsworth, California 91311
(805) 527-8630

(Bright ideas for your existing CAD system!)

CIRCLE NO 770



$3,250

Unfair Competition?

Buy a 386 Computer for the Price of a 286

- 80386SX-16 MHz 32-bit Processor, 2 MB RAM
- 12-Slot Backplane, Two Filtered Fans
- 250 Watt 0.5% Regulated Power Supply
- Shock Mounted 1.2 MB FD & 40 MB, 25ms HD
- 2 Serial, 1 Parallel Port, 101 Key Keyboard
- 3-in-1 Mounting: Rack, Desk, or Tower

Also available with 20/25MHz Processor • Call Now!

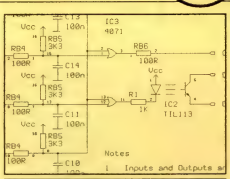
SMT™
1080 Linda Vista Drive
San Marcos, CA 92069
619-744-3590

CIRCLE NO 771

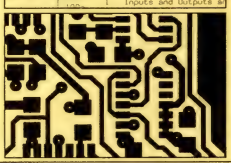
PCB and SCHEMATIC C.A.D.

EASY-PC $195

New Version:- Even Faster!!



"Excellent - EASY-PC does many things that our other £3,000 package doesn't!"
"It's delightfully easy to use! A really useful product."
"EASY-PC really deserves its BRITISH DESIGN AWARD"
"Very, Very good package!!"
"Elegantly simple...The best piece of software I've used!.."



Already used in over:-
206 Colleges, Universities etc.
38 Govt. Agencies
37 Telecom Depts.
15 Broadcast Depts.
And **thousands** of companies in 40 countries of the world.
Dealer Inquiries Welcome

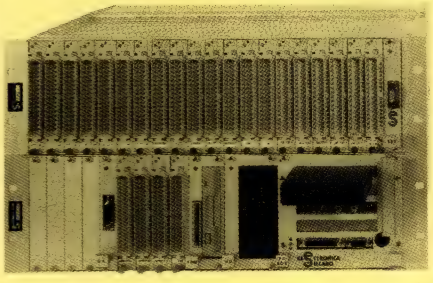
FAST Professional Quality Output at an Affordable Price

Write or phone for full details:-
Number One Systems Ltd. 1
REF: EDN, HARDING WAY, SOMERSHAM ROAD, ST. IVES, HUNTINGDON, CAMBS, U.K. PE17 4WR
Telephone
USA:- 011 44 480 61778
Intnl:- +44 480 61778
UK :- 0480 61778

AMERICAN EXPRESS
VISA
MASTERCARD (ACCESS)

CIRCLE NO 772

ES - BOX - SYSTEM



EUROCARD SMP BUS — IBM BUS

EUROCARD SMP BUS WITH 2ND CPU OPTION

BUFFERED OR DUAL PORT CONNECTION

THE RELIABLE AND POWERFUL WAY TO USE A PERSONAL COMPUTER IN INDUSTRIAL ENVIRONEMENT

- **word, byte and BIT digital I/O for easy and fast software**
- **Diagnostic signature on every I/O card**
- **Multiprocessor with dual port connection**
- **Complete software support**

AVAILABLE PERIPHERALS

* 6 ENCODER CONTROLLER *3 AXES CONTROLLER
* 16 THERMOCOUPLE CONTROLLER
* DIGITAL AND ANALOGIC I/O *FLOPPY MODULE
* HARD DISK MODULE *EPROM-RAM DISK CARD
* NETWORK CARDS (NOVELL, 10 NET) *MEMORY CARD
* RS232 CARD, REAL TIME CLOCK....

ELETTRONICA SILLARO S.R.L
COMPUTER PERIPHERALS AND INDUSTRIAL AUTOMATION
VIA MEUCCI,11
40024 CASTEL S. PIETRO T.
(BO) ITALY
TEL. 0039 51 940609
FAX 0039 51 941737
TLX 510160 ELSIL I
WE ARE LOOKING FOR DISTRIBUTORS

CIRCLE NO 774

New EPROM Programmer

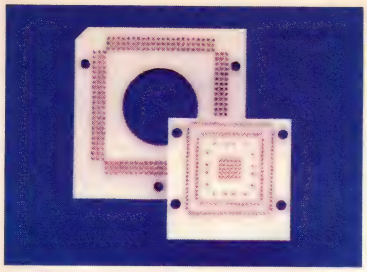


At $495, Wintek's Universal EPROM Programmer is a low-cost and versatile tool for programming most industry-standard EPROMs (2716-27256). Since it can operate with an IBM PC, as well as stand alone, the Programmer is ideal for use with PC-based microcomputer development software. Credit cards are welcome.

Wintek Corporation
1801 South St., Lafayette, IN 47904
(800) 742-6809 or (317) 742-8428

CIRCLE NO 775

To advertise in Product Mart, call Joanne Dorian, 212/463-6415

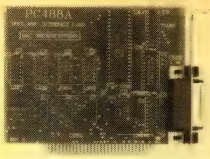


ISOCON™ SOLDERLESS CONNECTORS FOR HIGH DENSITY PAD PACKAGES

Compliant connection without package leads. Wiping action of conductors provides reliable gas-tight contact. Low inductance (<1 nH) and low total electrical resistance (<10 mOhms). High contact density, up to 400 I/Os per square inch at 50 mil pitch.

Rogers Corp., One Technology Drive
Rogers, CT 06263. 203/774-9605

CIRCLE NO 776



LOW COST INTERFACE CARDS FOR PC/XT/AT

RS-485/422 Card [PC485] $95/125

- Serial Async. Communication up to 4,000ft; 2 or 4 wires; NS16450 UART;
- COM1-4; Max. Baud Rate 56KB. **High speed version (256KB) - $165.**
- **Dual drivers/receivers;Handles 64 devices;**Compatible with most comm. S/W.
- DB9 or phonejack. **Sample programs included.**Optional S/W (w/ source)-$150

IEEE-488 Card [PC488A] $145

- Includes **INSTALLABLE DOS DEVICE DRIVER** and support for **BASIC.**
- Additional Support for **ASSEMBLY, C, Pascal** and **FORTRAN - $ 50.**
- **Selectable IRQ (1-6). DMA** channel 1 or 2. Up to **four boards** per computer.
- Compatible with most **IEEE-488 Software packages** for IBM-PC (e.g. **ASYSTANT-GPIB, Lotus Measure**). Compatible with NI's **GPIB-PCIIA.**

IEEE- 488 Card [PC488B] With Built-In Bus Analyzer $345

- Software Support for BASICA, QuickBASIC and GWBASIC (PC488C only)
- Additional libraries for **C, Pascal, FORTRAN, Assembly** available - **$50 (all)**
- **Powerful menu-driven BUS ANALYZER** runs in the background while 488 programs or commands are executed; Features **Program Stepping, Break points,** real time **bus data capture** (4K buffer), **instant screen toggling.**
- **Complete Controller / Talker / Listener** capability. Based on TI's **TMS-9914.**
- **NEC-7210** based card (compatible with National Instruments **PCII**) - **$445.**

Stepper Motor Card [PCL738] $395

- Capable of independent and simultaneous control of up to **3 stepper motors.**
- **Programmable speed** from **3.3 PPS** to **3410 PPS;** Built-in acceleration control.
- Step Position Read-back; **Opto-isolated outputs;** Crystal based timing.
- **Pulse/Direction** or **CW/CCW** pulse output. Includes **8 bit digital I/O port.**

MC / VISA / AMEX *Call today for datasheets!*

B&C MICROSYSTEMS INC.
355 West Olive Ave, Sunnyvale, CA 94086 USA
TEL: (408)730-5511 FAX: (408)730-5521

CIRCLE NO 777

8051



PC BASED EMULATORS

- Source Level Debug for PL/M and 'C'
- Source Level trace
- Debug with symbols, not HEX data
- Source Level disassembly with in-line assembler
- Interchangeable probe cards
- Up to 128K emulation memory
- 20 MHz real-time emulation
- Up to 4K trace buffer
- Performance analyzer
- TRUE 8051 Emulation including all I/O ports, idle, power down, DMA, and WatchDog timers at NO additional cost
- Breaks set symbolically
- Fully documented
- Serially linked to PC
- OEM supplier to 8051 IC manufacturers
- Unlimited FREE technical support
- From $1495*

MetaLink™...Originators of the PC Based 8051 Emulator

We have more 8051 emulators than anyone in the world: 8031, 8051, 8032, 8052, 8344, 8044, 80C152JA/JB/JC/JD, 83C152JA/JC, 80C452, 80C51FA, 80515, 80535, 80512, 80532, 80513, 80C517, 80C521, 80C541, 80C321, 8053, 8XC154, 8XC451, 8XC552, 8XC562, 8XC652, 8XC751, 8XC752, 80C537, CMOS, EPROMs, OTPs

Call or write for Free demo diskette

1-800-METAICE®

MetaLink® Corporation

MetaLink Corporation P.O. Box 1329, Chandler, AZ 85244-1329
(602)926-0797 FAX: (602)926-1198 TELEX:4998050 MTLNK
*Price is U.S. list

NOW 8XC552 & 80C517 SUPPORT

CIRCLE NO 778

DATA I/O PROGRAMMERS: GREAT, H/W FLEXIBLE.

SAILOR PROGRAMMERS: GREAT, S/W FLEXIBLE.

Find out why. Please call for a free demo disk.
Sailors support: ★ 7ns PALs ★ 12ns GALs
★ 2-MEG EPROMs ★ PROMs ★ EEPROMs
★ EP900 ★ EP1800 ★ 8751 and many more

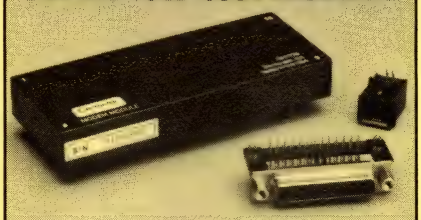


1-800-627-2456
FAX 408-736-2503
Advin Systems Inc.

Data I/O: trade mark of Data I/O Corp. ★ Sailor: trade mark of Advin Systems Inc.

CIRCLE NO 779

SUPER LOW COST MODEMS



- 1200, 2400, 4800, 9600 bps
- Standard or Custom Modem Modules or PCBs
- International or Domestic
- FCC Part 68 Approved
- Quick to Market/ Guaranteed Performance

Your Source for Modem Components:

Cermetek microelectronics

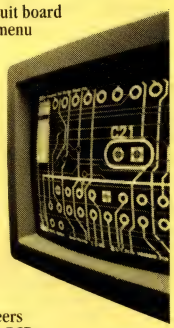
Tel: 408-752-5000
Fax: 408-752-5004

Cermetek Microelectronics, Inc.
1308 Borregas Ave. • Sunnyvale, CA 94089

CIRCLE NO 780

Again, "Best Value" in PCB Design.

Tango sets the pace in PC-based circuit board design with an easy-to-use, pop-up menu interface and powerful features including: 1 mil resolution; full SMT support; DRC; PostScript™ output; fast, high-completion auto-routers; and photoplot previewing. Configure your personal PCB design station from our selection of entry-level and expert tools, starting at just $595.



Tango™

For the second year in a row, engineers have rated Tango the "Best Value" in PCB design at CAD Showdown '90. Rich functionality, one year's updates, free tech support and BBS, plus our 30-day guarantee. Call today.

FREE EVALUATION PACKAGE
800 433-7801 619 554-1000 619 554-1019 Fax

ACCEL™ Technologies ■ 6825 Flanders Drive ■ San Diego, CA 92121 USA
International prices may vary. Contact us for the distributor nearest you.

CIRCLE NO 781

TESS

30-day money-back guarantee!

PC Block Diagram Simulation

Modems, DSP, satcom, nav, controls...
Times are tough: shorter schedules, more complexity. TESS can help you:

- Detect gotchas before breadboarding.
- Find the best design alternatives fast.
- See the effects: filters on signals & loops, ϕ-noise, multipath & adjacent channels.
- Simulate mixed-signal ASICs & systems.
- Put a lab on your desk for just $695!

Demo disk: 404-751-9785 Fax: 404-664-5817
TESOFT Box 305, Roswell, GA 30077

CIRCLE NO 782

$249. TERMINAL



Featuring
- Standard RS-232 Serial Asynchronous ASCII Communications
- 48 Character LCD Display (2 Lines of 24 each)
- 24 Key Membrane Keyboard with embedded graphics
- Ten key numeric array plus 8 programmable function keys
- Optional RS-422 multidrop protocol mode
- Keyboard selectable SET-UP features—baud rates, parity, etc.
- Size (5.625"W x 6.9"D x 1.75"H). Weight 1.25 lbs.
- 5 x 7 Dot Matrix font with underline cursor
- Displays 96 Character ASCII Set (upper and lower case)
- Optional Bar Code Wand (shown)

COMPUTERWISE, INC.
302 N. Winchester • Olathe, KS 66062 • 800-255-3739 • FAX (913) 829-0810

CIRCLE NO 783

WANTED

LAS Bug #331154



Stack Overflow

Locate him with the deep memory of the Logic Analysis System

4k to 64k memory depth
16 level triggering with pass counter
40 to 320 channels
A complete Logic Analyzer on a Card
Interactive software under Microsoft™ Windows
Source code in C for automatic testing

BitWise DESIGNS, INC.

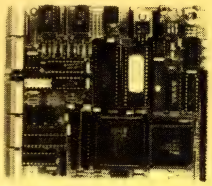
701 River Street
Troy, NY 12180
(800) 367-5906
(518) 274-0755
FAX (518) 274-0764

CIRCLE NO 784

To advertise in Product Mart, call Joanne Dorian, 212/463-6415

Little Giant™

C Programmable Controller

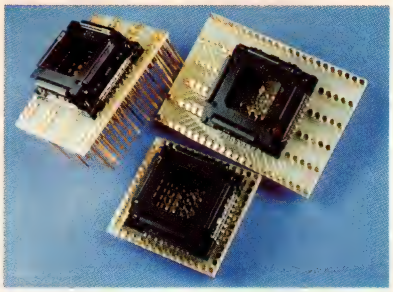


This shirt pocket sized computer interfaces directly to the outside world. Use it to control anything. Instantly programmable using your PC with Dynamic C. ROM and battery backed RAM to 1024k bytes. 8 Channel, 10/12 bit, A/D with conditioning. High voltage and current drivers. Battery backed time and date clock. Watchdog and power fail. 4 serial channels. 24 parallel ports. Timers. Integral power supply. Terminations for field wiring. Expansion connector. Plastic or metal field packaging available. OEM versions from $199.00.

Z-World Engineering
1340 Covell Blvd., Davis, CA 95616
(916) 753-3722
Fax: (916) 753-5141

CIRCLE NO 785

PLASTIC QUAD FLATPAK



PROTOTYPING

Plastic Quad Flatpak adaptors have been added to our line of **prototyping and test adaptors**. The device is constructed with all gold plated pins (soldertail or wirewrap) and the highest quality plastic quad flat pack sockets. Parts included in this line handle 84 to 164 pin devices. Ask about our custom design services for unique solutions in packaging.

IRONWOOD ELECTRONICS
P.O. BOX 21151, ST. PAUL, MN 55121
(612) 431-7025

CIRCLE NO 786

EPROM PROGRAMMER



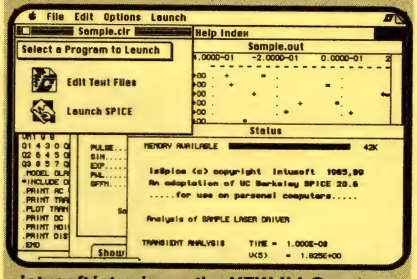
- **Quick pulse** pgms. eight 1 Mbit EPROMs in 40 sec.
- Stand-alone or PC-driven
- RS-232, **parallel** in & out ports
- Binary, Intel hex, & Motorola S formats
- 100 user-definable macros
- Information, call **(916) 924-8037**
- 1 Megabit of DRAM
- Made in U.S.A.
- A9 Identifier
- 2 year warranty
- Single pgmr. $550

NEEDHAM'S ELECTRONICS
4539 Orange Grove Ave. • Sacramento, CA 95841
(M - F, 8 - 5 PST)

CIRCLE NO 787

Analog Circuit Simulation

SPICE FOR THE MACINTOSH



intusoft **introduces the NEW !! IsSPICE/MAC,** The only Spice program to run on all Macintoshes (Plus, SE, SE/30 and Mac II) in as little as 1 megabyte of RAM. The simulatable circuit size is only limited by the amount of RAM. Coprocessor ($210) and Non-coprocessor ($95) versions are available. Also available is **PRESPICE/MAC** ($175) which contains extensive model libraries, the IsSPICE netlist editor and ICAPS, an easy to use menu system especially adapted for the MAC environment.

P.O. Box 6607
San Pedro, CA
90734-6607
intusoft
(213) 833-0710
30 Day Money
Back Guarantee

Macintosh is a registered trademark of Apple Computer

CIRCLE NO 788

SPECIAL OFFER

PHOTOPLOT
AUTOROUTE
SCHEMA PCB

PCB, PLOT & DRILL
Regularly **$2,025**
Special Price
all three **$1,495.**
You save **$530!**

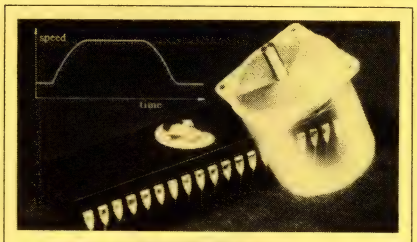
Mainframe PCB layout features for your PC... + FREE, ongoing, 1-800 support... + our 30 Day Money Back Guarantee!

FREE DEMO KIT
1-800-553-9119 **OMATION**

CIRCLE NO 789

Combine Your Product Mart Ads

In EDN's Magazine
and
News Editions for
higher impact and a
lower rate.



STEP MOTOR CONTROL
27K steps/sec! 16 Million steps!

New CY545. Rates up to 27K steps/sec, up to 16 million steps per single motion. Separately programmable start rate, accel/decel rate, and max rate. Pulse & direction output. External jog mode and limit switch detection. Serial or parallel interface, LED/LCD & Thumbwheel interface lines, and more. ASCII commands. Supports 64K external memory. CMOS 40-pin DIP. $75 each ($25/1000). Credit Cards OK.

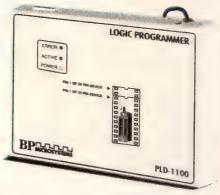
Cybernetic Micro Systems
Box 3000, San Gregorio CA 94074
(415)726-3000 Tlx: 910-350-5842

CIRCLE NO 791

There is a Difference.

Lifetime Free Updates

PLD-1100
$798



A programmer is not just another programmer. That is why BP Microsystems is commited to bringing our customers the highest quality programmers at an affordable price. The PLD-1100 Logic Programmer supports virtually every 20- and 24-pin logic device currently available. And, all of our programmers include free updates to support future chips as they become available and an unconditional money back guarantee.

BP MICROSYSTEMS
1-800-225-2102
(713) 461-9430

CIRCLE NO 792

Surface Mount Chip Component Prototyping Kits— Only $49.95



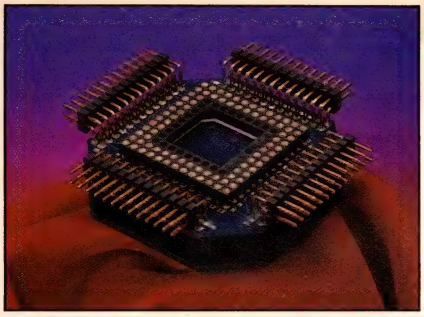
CC-1 Capacitor Kit contains 365 pieces, 5 ea. of every 10% value from 1pf to .33μf. CR-1 Resistor Kit contains 1540 pieces; 10 ea. of every 5% value from 10Ω to 10 megΩ. Sizes are 0805 and 1206. Each kit is ONLY $49.95 and available for Immediate One Day Delivery!

Order by toll-free phone, FAX, or mail. We accept VISA, MC, AMEX, COD, or Pre-paid orders. Company P.O.'s accepted with approved credit. Call for free detailed brochure.

COMMUNICATIONS SPECIALISTS, INC.
426 West Taft Ave. • Orange, CA 92665-4296
Local (714) 998-3021 • FAX (714) 974-3420
Entire USA 1-800-854-0547

CIRCLE NO 793

To advertise in Product Mart, call Joanne Dorian, 212/463-6415



Full Line of PQFP Adapters

- At the prototyping stage, use a PQFP Adapt-A-Board.™ Extends leads for easy wire wrapping.
- For emulation, use an Adapt-A-Pod,™ like the one shown here for an 80386 PQFP package. Just plug and play.
- For production testing, a Bug Katcher™ turns your PQFP into an IC so you can start testing—ASAP.
- We stock all types of PQFP adapters. Quick turnaround on custom orders. Free catalog.

Emulation Technology, Inc.
2368-B Walsh Ave. Santa Clara, CA 95051
Phone: 408-982-0660 FAX: 408-982-0664

ET

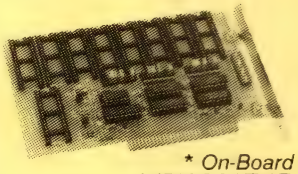
CIRCLE NO. 201

Create a DISKLESS PC

IT's EASY..IT's SIMPLE.....
THERE's Nothing to it!!!

PROMDISKtm III

IBM PC DISK EMULATOR CARD



* On-Board BIOS ROM
* IBM PC/XT/AT Compatible
* Mix EPROMs, EEROMs, SRAMs
* Emulates up to 1.024Mbyte Drive
* Occupies 32K PC address space
* Supports popular Byte-Wide chips
* Includes PROMDISKtm III Software

For Information Call or Write:
MICRO COMPUTER SPECIALISTS, INC.
810-208 Los Vallecitos
San Marcos, CA 92069
(619) 744-8087

CIRCLE NO. 202

OrCAD

Answers the PLD Challenge

OrCAD, makers of the most popular EDA tools in the world, offer incredible power and ease-of-use in **OrCAD/PLD**. Imagine a $495 product that includes testing capabilities, JEDEC or hex output and 7 forms of input including Boolean equations, state machines, truth tables, indexed equations, logic synthesis and schematic entry.

Call for a free demo disk and guide. (503) 690-9881.

OrCAD®

CIRCLE NO. 203

8086 8051 8096

ROYALTIES

Multi-Tasking EXECS

6800 6800 68HC11 Z80

U S Software offers hi-performance software tools for embedded applications.

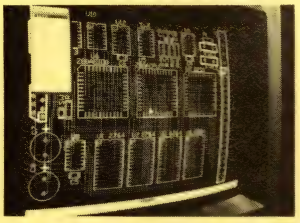
Get the full details by calling:

800-356-7097
503-641-8446
503-644-2413 (FAX)

U S SOFTWARE

United States Software Corporation
14215 NW Science Park Drive
Portland, Oregon 97229

CIRCLE NO. 204



Why Do Designers Choose Protel ?

Protel gets the job done !

Professional Quality CAD Tools

Protel offers a full suite of PC-based high-performance PCB design tools with easy-to-use & consistent user interfaces, free tech & EMS support, BBS and 30-day money-back guarantee.

Schematic $495
Popular precision digital and analog schematic design.

Autotrax $1295
Complete PCB layout with automatic placement & routing for both through-hole and SMD designs. Supports standard printing/plotting formats and up to 4MB EMS

Traxstar $1495
Powerful multi-layer rip-up and re-try autorouter. Handles over 700 ICs and a board of up to 20x32 inches.

Traxview $695
Full-featured interactive Gerber viewer and editor with automatic panelization for multiple Gerber files.

Before you invest in a PCB design product tomorrow: Call toll free (800) 544-4186 for one of our free demo-disks today.
in CA, HI, AK, or Canada, call: (408) 437-7771

Dealer Inquiries Welcome

Protel Technology

Protel Technology Inc.
50 Airport Parkway (408) 437-7771
San Jose, CA 95110 fax (408) 437-4913

CIRCLE NO. 205



LOW COST Data Aquisition Cards for PC/XT/AT

12 Bit A/D & D/A [PCL711S] $295
- **A/D converter:** 8 single-ended channels; Uses **AD574** device; Conversion time is less than 25μsec; Input range: ±5V; Software Trigger Mode only.
- **D/A converter:** 1 channel; 12 bit resolution; 0 to **+5/10V** Output Range.
- **Digital I/O:** 16 In/Out(TTLcompatible); External Wiring Terminal Board incl.
- **Utility Routines** and **Demo/Sample Programs** for **BASIC** and **Quick-BASIC**.

12 Bit A/D & D/A [PCL812] $395
- **A/D converter:** 16 single ended inputs; Uses AD574; Conversion time less than 25μsec; Built-in programmable pacer; Input Ranges: ±10V, ±5V, ±1V.
- **D/A converter:** 2 channels; 12 bit resolution; Output Range 0-5V.
- **Digital I/O:**16In/Out(TTLcompatible); **Programmable Counter/Timer** (8254).
- **DMA** and interrupt capability. Utility software and sample program in BASIC.

Fast 12 Bit A/D/A [PCL718] $895
- **A/D converter:** 16 single ended or 8 differential channels; 12 bits resolution; Programmable scan rate; Built-in Interrupt and DMA control circuitry. Conversion speed **60,000 smpls/sec** (standard), **100,000 smpls/sec** (optional).
- Input Ranges:Bipolar : ±10V, ±5V, ±2.5V, ±1V, ±0.5V; Unipolar:10,5,2,1V
- **D/A converter:** 2 channels; Resolution: **12 bits;** Settling time: **5μsec;** ±5V
- **Digital I/O:**16In/Out(TTLcompatible); **Programmable Counter/Timer** (8254).
- **Software:** Utility software for BASIC & QuickBASIC included. Sample prgm. Supported by **LabDAS, ASSYST, LABTECH, UnkeScope.**

6 Channel 12 bit D/A [PCL726] $495
- **Output Ranges:** 0 to +5V, 0 to +10V, ±5V, ±10V, or sink 4-20mA.
- Settling time: **70μS.** Linearity: **±1/2bit.**Voltage output drive capacity: **±5mA.**
- **Digital I/O:** 16 digital input and 16 digital outputs (TTL compatible).

MC / VISA / AMEX *Call today for datasheets!*

B&C MICROSYSTEMS INC.
355 West Olive Ave, Sunnyvale, CA 94086 USA
TEL: (408)730-5511 FAX: (408)730-5521

CIRCLE NO. 206

EMI?

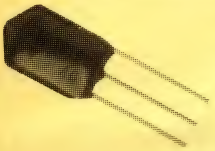
Take One – Pass FCC

Now in the USA the patented Filmac® EMI filters from Japan. Find out why they are used by most big Japanese makers to pass FCC class B.



- Low cost
- Capacitor like construction
- Distributed low pass filter
- Sales over 1 million pcs /month
- Better results than built up filters

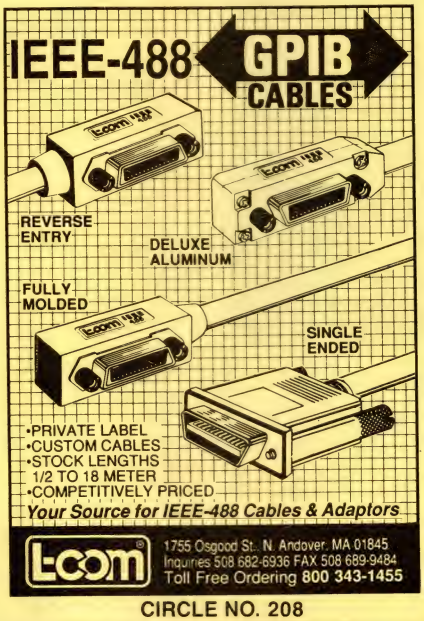
Free! 26 piece sample kit. Call today.



800-899-7888
Zyrel, Inc.
1900 McCarthy Blvd.
Suite 201
Milpitas, CA 95035

CIRCLE NO. 207

IEEE-488 GPIB CABLES



•PRIVATE LABEL
•CUSTOM CABLES
•STOCK LENGTHS
1/2 TO 18 METER
•COMPETITIVELY PRICED

Your Source for IEEE-488 Cables & Adaptors

L-COM®
1755 Osgood St., N. Andover, MA 01845
Inquiries 508 682-6936 FAX 508 689-9484
Toll Free Ordering **800 343-1455**

CIRCLE NO. 208

Gridless, 100% Autorouting



Create and revise schematics and PCBs quickly and simply with **HiWIRE-Plus®** and your IBM PC. With the new, gridless, multilayer autorouter (AR) for HiWIRE-Plus, creating printed-circuit layouts is even faster. AR and HiWIRE-Plus are each $895 and come with thirty-day money-back guarantees. Credit cards are welcome.

Wintek Corporation
1801 South Street, Lafayette, IN 47904
(800) 742-6809 or (317) 742-8428

CIRCLE NO. 209

To advertise in Product Mart, call Joanne Dorian, 212/463-6415

CAREER OPPORTUNITIES

1990 Recruitment Editorial Calendar

Issue	Issue Date	Ad Deadline	Editorial Emphasis
Magazine Edition	July 19	June 28	Product Showcase—Volume II: CAE/ASICs, Computers & Peripherals, Components, Test & Measurement
Magazine Edition	Aug. 2	July 12	Digital ICs/Microprocessors, Computer-Aided Engineering, Computers & Peripherals, Test & Measurement, Technical Article Database
News Edition	Aug. 9	July 20	CAE/Software, Aerospace, Special Supplement: Defense
Magazine Edition	Aug. 20	July 30	Military Special Issue, Vision/Image Systems, ICs & Semiconductors, Memory Technology, Software
News Edition	Aug. 23	Aug. 3	Electromechanical, Opportunities in Non-EOEM, Regional Profile: New Mexico, Arizona
Magazine Edition	Sept. 3	Aug. 13	ASICs Special Issue—Semicustom ICs, Computer-Aided Engineering, Digital Components, ICs & Semiconductors
News Edition	Sept. 6	Aug. 17	CAE/Software, CASE/CAE, Special Supplement: DSP
Magazine Edition	Sept. 17	Aug. 27	System Software, Computer-Aided Engineering, Analog ICs, Digital ICs

Call today for information on Recruitment Advertising:
East Coast: Janet O. Penn (201) 228-8610
West Coast: Nancy Olbers (603) 436-7565
National: Roberta Renard (201) 228-8602

ENERGETIC WORK FORCE. ENERGETIC WORK SOURCE.

Skilled, hard-working co-op students from Stevens Institute of Technology to lighten your load in nine engineering fields. Call our Office of Cooperative Education at 201-420-5368.

STEVENS

CIRCLE NO. 230

If You're Looking For a Job, You've Come to The Right Place.

EDN CAREER OPPORTUNITIES

EDN Magazine Edition News Edition

ORCHESTRATING DESIGN SOLUTIONS

FINE TUNED

At Cadence, we're the leader in IC Design Automation. In fact, we just became the industry's newest $100 million company. But we're already looking ahead. And fine tuning our performance. We're determined to become the leader in the overall Electronic Design Automation (EDA) market. And we're positioned to succeed.

We have software tool development teams that cover the entire spectrum of EDA, including IC, CAE, Systems, and Analog. While our products are diverse, they all possess unique integration capabilities and can be ported to any popular workstation. If you're a finely tuned performer who'd like to help us shape an industry, contact Cadence.

IC R&D

- Director of Module Generation Tools
- Solutions Engineering Manager
- Porting Manager
- Software Development Engineers
  - Data Translation
  - Layout Verification
  - Software Porting
  - Hierarchal Design Planner
  - Technology Partner Support
  - Place & Route
  - Auto Place & Route
  - Interactive Graphics

Refer to Job 3100-EDMRD/HK

SYSTEMS R&D

- Software Development Engineers
  - Design Entry
  - CAE Library Development
  - User Interface
  - Simulation Interface
- Applications Engineering Director
- Program Manager
- Applications Engineers
- UNIX* Systems Administrator
- Software QA Engineer

Refer to Job 4810-EDMRD/MC

ANALOG R&D

- Software Development Engineers
  - Library Development
  - Simulation Interface
  - Place & Route
- Marketing Manager
- Channel Marketing Specialist
- Software QA Engineer

Refer to Job 4610-EDMHK

APPLICATIONS ENGINEERING

- Applications Engineers
  - Place & Route
  - ASIC Place & Route
  - Module Generation Tools
  - CAE
  - Custom Layout and PDV
  - SYMBAD®
  - Plotting and License Manager

Refer to Job 2200-EDMJC

OPERATIONS

- ASIC Place & Route Systems Training Engineer
- Framework/SKILL Systems Training Engineer
- Senior Software QA Engineer
- Software QA Verification Engineer
- Manufacturing Software Engineer
- Senior Technical Editor
- Senior CAE Technical Writer
- Senior Auto Layout Technical Writer
- Senior Framemaker Production Editor
- Framework Technical Writer

Refer to Job 5100-EDMHK

CORPORATE QUALITY

- CASE Director/Manager

Refer to Job 3560-EDMJC

CORPORATE MIS

- Senior Oracle Systems Administrator
- UNIX Telecommunications Manager
- UNIX Network Analyst

Refer to Job 4180-EDMHK

MARKETING

- Framework Product Marketing Manager
- Product Marketing Engineers
  - ASIC Place & Route
  - Logic Synthesis
- Simulation Product Manager
- Account Manager
- EDA Public Relations Representative

Refer to Job 1100-EDMMC

ADVANCED CAE DIVISION

Lowell, MA

The Advanced CAE Division of Cadence is involved in HDL-based design entry and analysis, simulation technology (Verilog,® VHDL) and modeling. We have positions open on all levels for Software Engineers and Project Leaders in Lowell, MA and San Jose, CA.

Refer to Job ACD-EDMEM

FAX US YOUR RESUME
408-954-8766

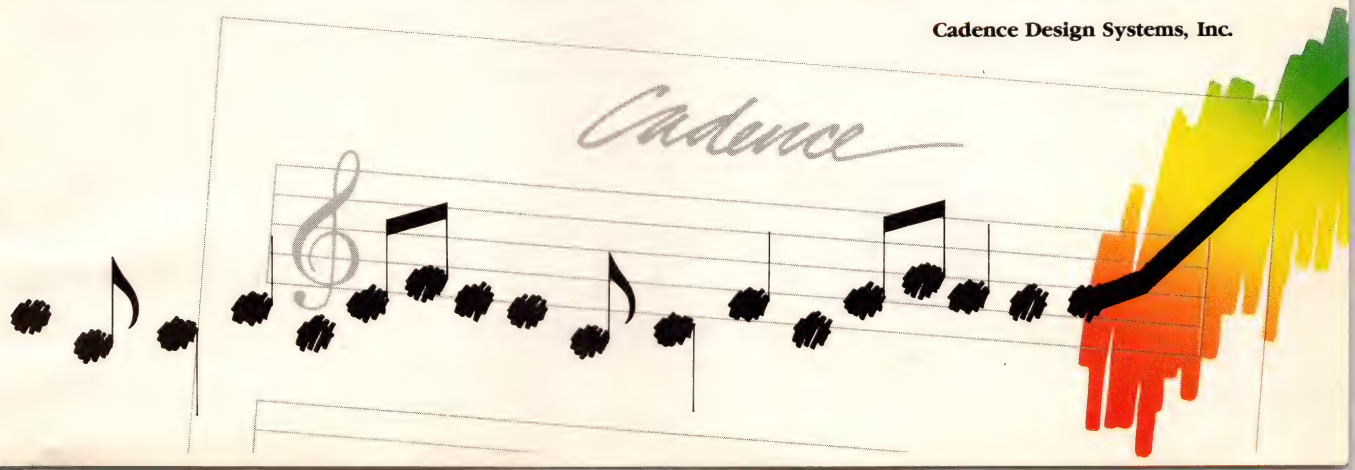
INDICATING APPROPRIATE JOB NUMBER

Cadence is a great place to work! Our highly competitive compensation and benefits package includes medical/dental/life insurance, vision care, a stock option program and a recently approved employee stock purchase plan (effective July 15, 1990), 401(k), a flexible benefits plan, 11 paid holidays, and educational assistance. If unable to FAX, please mail your resume, indicating appropriate Job number, to: Cadence Design Systems, Inc., Human Resources, 555 River Oaks Parkway, San Jose, CA 95134. We are an equal opportunity employer.

*UNIX is a registered trademark of AT&T.

CADENCE™

Cadence Design Systems, Inc.





VLSI IS HAPPENING.

The future is something VLSI has been preparing for since our inception. Our ASICs are ahead of their time and because of it, our customers are a step ahead of the competition. Now it's your chance to participate in the excitement.

Because right now, VLSI is happening.

Our ASICs put the power and value in the world's most popular machines. Our customers are already taking advantage of our 1-micron technology, and the highest integration solutions on the market. And with our highly automated design capabilities and robotic manufacturing processes, they get their semiconductors in record time. But there is a lot of unclaimed territory left to explore, and we need original thinking to match the demands of our future development.

History in the making.

You can be the vital force, the essential element behind the next landmark in our continual new product evolution. We presently have excellent opportunities for high caliber professionals with relevant semiconductor industry experience and education credentials.

ASIC & MEMORY DIVISIONS:
San Jose, CA

- **Engineering Managers**
- **Analog Circuit Designers**
- **Digital Design Engineers**
- **Applications Engineers**
- **Device Engineers**
- **Field Sales Engineers**
- **Library Development Engineers**
- **Packaging/Assembly Engineers**
- **Software Development Engineers**
- **Process Engineers**
- **Product Marketing Engineers**
- **Product Engineers**
- **Reliability/QA Engineers**
- **Technical Support Engineers**
- **Programmer/Analysts**

We also have positions available at the following locations:

TECHNOLOGY CENTERS & SALES OFFICES:
Phoenix, AZ • Irvine, CA • San Fernando Valley, CA • San Jose, CA • Ft. Lauderdale, FL
Chicago, IL • Boston, MA • Dallas, TX • Princeton, NJ

LOGIC & GOVERNMENT DIVISIONS:
Phoenix, AZ

MANUFACTURING OPERATIONS:
San Jose, CA • San Antonio, TX

We support innovation and reward success. So send us your resume today. Because VLSI is one happening that promises to continue for a long time. We offer a competitive salary and an outstanding benefits package. Please send your resume, indicating position and location desired, to VLSI Technology, Inc., Professional Staffing, Dept. KG-EDN, MS01, 1109 McKay Drive, San Jose, CA 95131. We are an equal opportunity employer.



VLSI TECHNOLOGY, INC.

IT'S HAPPENING HERE

With a career at Motorola Cellular, we see no end in sites.

Stretching from the U.S. throughout the Far East, Latin America and Europe, Motorola cell sites cover the world. In fact, the company that pioneered cellular communications is now outdistancing all competitors combined. We're bringing the worldwide telecommunity closer and paving the way for even greater breakthroughs...like our patented four-cell reuse plan that supports more voice channels with fewer cell sites.

And with just 1% of the global cellular market developed, the opportunities at Motorola Cellular have just begun. We're developing the most advanced software, switching equipment and radio telephone exchanges. We're constantly modifying, updating and simplifying systems while enhancing RF sector-sharing capabilities.

Flexibility, capability and expandability...that's what Motorola Cellular can offer its customers...and your engineering career. If you want a career as dynamic as our growth, set your sites on one of the following opportunities: **• Software Engineers • Hardware Engineers • Test Equipment Engineers • Mechanical Engineers • Manufacturing Engineers • Cellular Systems Engineers.**

We offer an attractive salary, a comprehensive benefits package and opportunities for professional growth. For immediate consideration, please send your resume to: Supervisor, Professional Recruitment, Motorola Inc., Cellular, 1501 West Shure Drive, Arlington Heights, IL 60004. Or FAX your resume to: (708) 632-5717 (our 24-hour FAX line). To access our On-Line Career Network from your PC, dial (508) 263-3857, press return twice, and key in password LEGACY. We are an equal opportunity/affirmative action employer.

1990
1991
1992
1993
1994

MOTOROLA

Cellular Subscriber Group

Radio Telephone Systems Group

ge • Growth • Achievement • Momentum
• Technology • Challenge • Growth • Acl
um • Success • Excitement • Technology •
h • Achievement • Momentum • Success •
gy • Challenge • Growth • Achievement
• Excitement • Technology • Challenge • C

Acuson.

What's important to you?

Is being part of a team of technically elite engineering professionals developing state-of-the-art computer systems important? Is contributing to the development of life-saving medical technology important? Since 1982, Acuson's ultrasound imaging systems have allowed the medical profession to get a better look inside the human body using ultrasound waves. At Acuson, you are contributing to the development of truly significant medical technology. If this is important to you, it's time we got acquainted.

Digital Signal Processing Manager

You will manage the department that is responsible for the specification, design, characterization, and verification of embedded signal processing and DSP functions for a sophisticated medical imaging system. You will actively contribute to research and design activities. These will include algorithm design, signal path modeling and characterization, high speed hardware/software architecture synthesis, experimental verifications, and subsystem modeling, simulation, and debugging.

To qualify, you will need an MSEE or PhD degree or equivalent and at least 10 years of experience. Experience leading high performance design projects from concept through delivery to production is essential. Experience with digital VLSI ASIC methodologies and DSP microprocessor implementations is preferred. The ideal candidate will have experience in the development of state-of-the-art instruments, communications, or image processing systems. Position Code JT/DSP.

Analog Manager

You will manage a department responsible for delivering analog subsystem designs and board level circuit designs for a sophisticated medical imaging product. You will also be an active technical contributor to design activities –including performance studies, architecture design, module development, and transfer to manufacturing. Projects involve transducer interfaces and signal processing circuit designs for DC to one hundred megahertz with state-of-the-art performance requirements in areas of noise, bandwidth, dynamic range, as well as packaging and manufacturing features.

You will need combined systems and circuit design experience in a broad arena of signal processing applications. Ten years of engineering experience including a 2 year management background is required. Experience leading high performance analog circuit design projects from specification through delivery is essential. Familiarity with advanced packaging methodologies, analog ASICs, and DSP applications are preferred. Position Code JT/AM.

Acuson offers an excellent compensation program, including stock options and profit sharing. Please FAX (415) 967-4791 or send your resume, indicating Position Code to Acuson, 1220 Charleston Road, P.O. Box 7393, Mountain View, CA 94039-7393. EOE

acuson
COMPUTED SONOGRAPHY

Telecommunications Professionals

Seiscor Technologies, Inc. a manufacturer of telephone transmission equipment and a subsidiary of Raytheon, a Fortune 500 company, has immediate openings in Tulsa for the following positions:

Digital Hardware Design Engineer

Qualifications include a B.S. in Electrical Engineering, two plus years digital/microprocessor experience, PLD/ASIC and/or digital telephony experience helpful, ISDN experience/fiber optic experience desirable.

Sr. Analog Design Engineer

Requires a B.S.E.E. with three to five years experience in designing Line Cards for Digital Loop Carrier. Knowledge of Bell LSSGRs, TR-57 and TR-303 is a must. SLIC, ASIC, and SMT background is desirable.

Software Engineer

Qualified candidates should posses a B.S. in Computer Science or Electrical Engineering, three to twelve years experience in design, development and test with emphasis on microprocessor, real time software and telephone transmission products using C language.

Test Engineers

Provide test detail designs, including test procedures, programs and figures for production testing. Requirements include a B.S. in Electrical Engineering, three to five years telecommunications manufacturing experience, and Automatic Test Equipment experience.

Tulsa is an unusually clean and safe city with a high quality of life. You'll find pleasant year-round weather, rolling hills and several area lakes, low cost of living, easy commuting and light traffic. Tulsa is a good family town with an area population of 800,000, diverse cultural activities and good schools.

Call Personnel at 1-800-331-4048 or send resume to:

Seiscor Technologies, Inc.
PO Box 470580
Tulsa, OK 74147-0580
or Fax to 918-252-2757

An Equal Opportunity Employer, Affirmative Action Employer, M/F/V/H
U.S. Citizenship or U.S. Permanent Residence Required

Seiscor Technologies
A **Raytheon** Company

EDN's INTERNATIONAL ADVERTISERS INDEX

Academic Press 332
ACCEL Technologies Inc 337
Actel 79
Advanced Analog 112
Advanced Digital 331
Advanced Micro Devices 12-13
Advin Systems Inc 337
Aerospace Optics 81
Allen-Bradley Co 134
ALS Design Corp* 304, 333
Altera Corp 70-71
Amerace Corp 286
American Research and Engineering 297
AMP 214-215
Ampro Computers Inc 209
Anadigics 325
Analogic Corp 213
Ancot Corp 137
Annabooks 334
Antex Electronics 50
Asem Industria** 85
Atlanta Signal Processors Inc 202
AT&T Technologies . . . 147, 298-299
Augat 121
Augat-Alcoswitch 302
Avantek 59
BanComm 300
B&B Electronics Mfg Co 339
B&C Microsystems 335, 337
Belden Wire & Cable C4
Bitwise Designs Inc 337
Bourns Trimpot/Networks 197
BP Microsystems 332, 338
Bussmann 281
Cadence 86-87, 182-183
Cadisys 333
CAD Software Inc 175
CAD Utility 336
Cahners CAPS 293, 295
Calcomp 275
Capital Equipment Corp 56
Ceibo Ltd 331
Cermetek 337
Cherry Electrical Products Inc . . 335
Chomerics Inc 294
Circuit Search 332
Communications Specialists Inc 338
Component Mfg Service Inc . . . 228
Computerwise Inc 337
Condor 188
Coopertools* 145
Copley Controls Corp 336
Crystal Semiconductor 20
Cybernetic Micro Systems 333, 338
Cypress Semiconductor 23
Dale Electronics Inc 1, 50
Data I/O Corp 335
Datakey 25
Data Translation Inc 51
Datel* 274
Densitron 290
Design Computation Inc 332
Dialight Corp 223
Digital Equipment Corp* 32-33
DTK 99
Du Pont Electronics 309, 311, 313, 314-315
Du Pont Pixel Systems** 127
Duracell 243
Dynamic Soft Analysis 334
Ectron Corp 148
Electtronica Sillaro 336
Emerson & Cuming Inc 301
Emulation Technology Inc 339
Endicott Research Group 306
Epson America Inc 277
Ericsson Components 216
Exabyte Corp 241
Force Computers Inc* 30-31
Fujitsu Component of America* 289
GE Plastics 282, 283, 284-285
Goldstar Technology 269
Graphtec Corp 181
Grayhill Inc 382
GS Battery Inc 228
Hansen Co 291
Hantronix Inc 212
Harris Semiconductor 262-263
Heurikon Corp 2
Hewlett-Packard Co . . . 88, 88a-b, 89, 125**, 317*
Hoffman Engineering 259
Honeywell Test Instrument Div . . 305
HyperLynx 335
Hypertronics Corp 246
IDT 92
IEEE 311
IERC 292
ILC Data Device Corp 90
Inmark 335
Inmos** 10-11
Integrated Silicon Systems 76
Intel 95
International Rectifier 114
Intusoft 338
IOtech Inc 48
Ironwood Electronics Inc 338
Ivex 333
John Bell Engineering 334
John Fluke Manufacturing Co Inc* 126-127, 198-199
Kepco Inc 186-187
Keytec Inc 331
Lattice Semiconductor Corp 83
L-Com Inc 339
Leasametric Inc 292
LeCroy Corp 271
Lemo USA Inc 335
Lien Engineering Inc 332
Linear Technology Corp 264
Link Computer Graphics Inc . . . 334
Logical Devices Inc C2
LSI Logic Corp 14-15
3M Co 144, 346
Matsuo Electronics 309
McKenzie Technology 333
MCSI 339
Meade Instruments 103
Mental Automation 336
MetaLink Corp 337
Meta Software Inc 179
Micrel 117
Micronas 318
Micron Technology 108-109
Micro/Sys 333
Microwave Logic 333
Mini-Circuits Laboratories 3, 4, 60-61, 126-127, 267
Mitsubishi Electronics America Inc 66-67, 165
Mizar Inc 180
Molex Inc 348
Motorola Semiconductor Products Inc . . . 110-111 128-129
Multibus Manufacturers Group 101
National Instruments* . . . 35-46, 310
NCR Corp 52-53
NEC Corp 138-139, 316
NEC Electronics Inc 72-73
Nohau Corp 331
Noise Laboratory Co 34
Number One Systems Ltd 336
OKI Electric 184-185
OKI Semiconductor 28-29
Omation Inc 338
OrCAD Systems Corp 8, 339
Pacific Hybrid Microelectronics 305, 306
PEP Modular Computers . . 149-164
Philips Components** 32-33
Philips Discrete Products Div* . 88-89
Philips T&M** 30
Pico 288, 319
Planar Systems 334
Powertec, A div of Astec America 102
Precision Concepts 137
Precision Interconnect 195
Precision Monolithics Inc 347
Presco 332
Protel Tech Inc 339
Pulizzi Engineering 331
Qualidyne Systems Inc* 196a-d
Qualogy 177
Qua Tech Inc 332
Radstone Technology 303
Raytheon 166

EDN's INTERNATIONAL ADVERTISERS INDEX

Rayovac 68
RCG Research 331
RLC Enterprises 334
RLM Research 335
Rockwell Elec Oprtn 244-245
Rogers Corp 333, 337
Rohde & Schwarz** 145
Samsung Semiconductor 16-17
Samtec Inc 308
SBE 74
Seagate Technology 57
Selco Products Inc 332
Sematech 320
Semikron Inc 119
SenSym 278
SGS-Thomson Microelectronics* 10-11
Siemens* 321
Siemens AG** 198-199
Siemens Components Inc* 85
Silicon Systems Inc 97
Sipex Corp 136
S-MOS Systems* 104-107, 105-106
Sony Component Products 141
Sophia Systems Inc 211
Stimpson Co Inc 212
Systems Manufacturing Tech . . . 336
Tatum Labs 333
T-Cubed Systems Inc 334
TDK Corp of America 229-236
TEAC Corp** 74
Tek* 131-132
Tektronix* 130-133
Teledyne Relays 287
Television Equipment Assoc Inc 336
Tesoft 337
Texas Instruments Inc* 62-65, 63-64
Thomas and Betts Corp 296
Tokin Corp 124
Tong Hsing Electronic Ind Ltd** . 274
Toshiba America Inc/ Semiconductor 200-201
Tritech 332
Unicorn Microelectronics Corp 260-261
United Micro Corp** 31
Universal Data Systems C3
US Software 335, 339
Vicor 123, 143
Visionics Corp 58
VMETRO 280, 323
Westcor 6
Western Digital 54-55
Wintek Corp 334, 336, 339
Xeltek 146
Zilog Inc 49
Z-World 338
Zyrel Inc 339

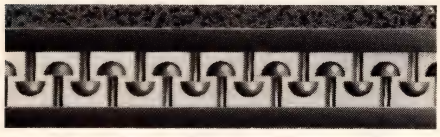
Recruitment Advertising 340-344
Acuson
Cadence
Motorola Cellular Group
Seiscor Technologies
Stevens Inst of Technology

*Advertiser in US edition

**Advertiser in International edition

This index is provided as an additional service. The publisher does not assume any liability for errors or omissions.

Faster fasteners for access panels.



Dual Lock™ brand Reclosable Fasteners



Scotchmate™ brand Hook and Loop Reclosable Fasteners

With 3M's reclosable fasteners, access panels and doors simply pull open and push shut. These fasteners have a strong, pressure sensitive adhesive backing for immediate attachment and long-term performance. They replace cumbersome and unsightly conventional fasteners, eliminating the need to drill holes and refinish surfaces. So production is faster, manufacturing costs less and access is easier.

©1989 3M. "Scotchmate" and "Dual Lock" are registered trademarks of 3M.

FREE SAMPLES. For more information and free samples of 3M fasteners, mail to 3M Industrial Specialties Division, 3M Center Bldg. 220-7E-01, St. Paul, MN 55144-1000.

Name_____

Company_____ Phone_____

Address_____

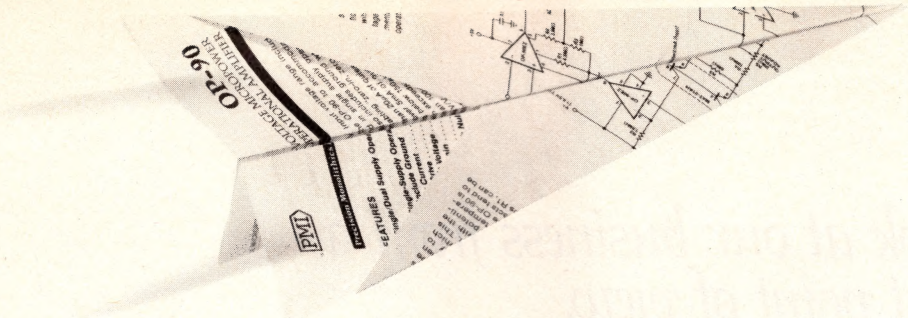
City_____ State____ Zip_____

☐ Please have a sales representative call me. **EDN062190**

3M

CIRCLE 104 FOR SALES ASSISTANCE

CIRCLE 105 FOR INFORMATION



More Precision. Micro Power. Mini Price.

Power is costly . . . but PMI's broad line of micropower/low power op amps is not. And, all come with the precision performance you've come to expect from PMI.

We've got them all – singles, duals, quads– with supply current as low as a mere 200nA. Check the table for the PMI micropower/ low power op amp that meets your needs at new lower prices!

All of our devices are available in small outline (SO) packages plus plastic DIP, CerDIP, LCC, and as dice. And, we've extended the temperature range from 0°C/70°C to –40°C/+85°C to bring you added value at no extra cost. Full 883 versions available too, of course!

PMI's Micropower/Low Power Op Amp Family

	Single	Dual	Quad	Max I_{SY} per Amp	Max V_{OS} (single)
Precision, µPower	OP-90	OP-290	OP-490	20µA	150µV
General Purpose	OP-20	OP-220	OP-420	55µA	250µV
Fast	OP-21	OP-221	OP-421	230µA	100µV
Programmable	OP-22	—	—	200nA - 400µA	300µV
Fast, Programmable	OP-32	—	—	200nA - 2mA	300µV
Low I_B, CMOS	OP-80	—	—	325µA	1.5mV
Precision, Low Power	OP-97	OP-297	—	600µA	25µV

If you need a cost-effective solution to your amplifier requirements, call us first at **(800) 843-1515** or FAX us at (408) 727-1550. Or, circle the reader service number below for information on the industry's broadest family of micropower/ low power op amps.

PMI®

PMI – your partner in analog integrated circuits.

Precision Monolithics Inc.
1500 Space Park Drive
Santa Clara, California 95054-3434

ALTAMONTE SPRINGS: (407) 831-8233, **ATLANTA**: (404) 263-7995, **BOSTON**: (508) 794-0026, **CHICAGO**: (312) 250-0808, **DALLAS**: (214) 690-3495, **DENVER**: (303) 792-9595, **DETROIT**: (313) 930-2051, **LOS ANGELES**: (818) 886-6881, **MILPITAS**: (408) 263-9366, **ORANGE COUNTY**: (714) 637-9602, **PHILADELPHIA**: (215) 953-1070

We look at our business from a different point of view.

Yours.

With the pressures of bringing your products to market today, you need an electronic components supplier who can not only fulfill your needs, but anticipate them. One who will share your concerns, understand your design parameters, and appreciate your way of doing business.

In this fast-paced global marketplace, you should be getting more than good products from your connector maker. You should have the assurance of the people behind the product. People whose commitment to you goes beyond the sale.

You can find this commitment in every division, every department at Molex. From the R&D and advanced engineering groups who help you improve your designs, products and turnaround time...to manufacturing and shipping people, who work to assure consistent quality and on-time delivery, whether in Chicago, Munich, Tokyo, or Singapore.

You don't have to have a problem to enjoy the connector expertise of our sales engineers. They'll come to you with practical ideas, technology, and suggestions for improvements wherever you are in the world.

Understanding your business and helping. That's what makes Molex a valuable player on any team.

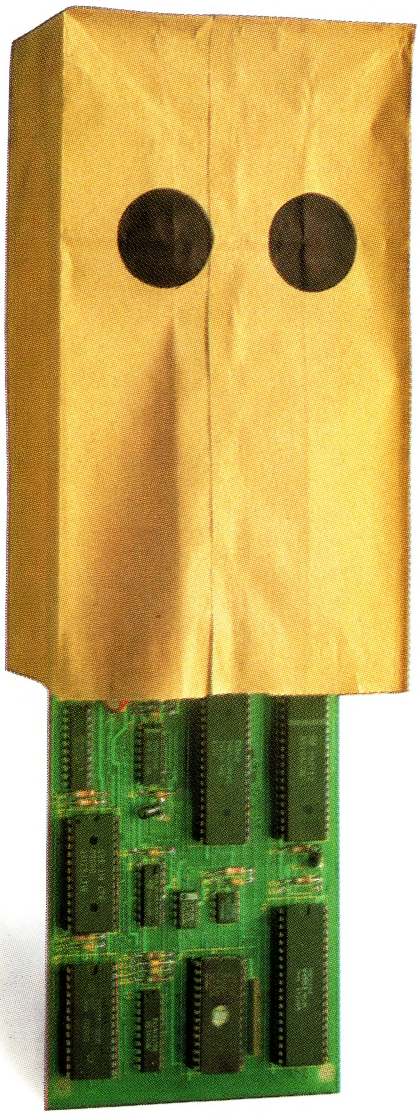


molex®

Bringing People & Technology Together, Worldwide℠

Corporate Headquarters: *2222 Wellington Ct., Lisle, IL 60532 U.S.A., Tel: (708) 969-4550* • ***European Headquarters:*** *Munich, West Germany, Tel: 49-89-413092-0*
Far East North Headquarters: *Tokyo, Japan, Tel: 81-427-21-5539* • ***Far East South Headquarters:*** *Jurong Town, Singapore, Tel: 65-660-8555*

© 1990, Molex Incorporated



We build anonymous modems for our famous friends

Some of our best OEM customers don't want to be identified; we understand. They're among the world's leading suppliers of computers, intelligent terminals, graphics and engineering workstations and other equipment that requires built-in data communications capability.

These well-known companies have selected UDS as their modem supplier because we provide front-running technology, superb manufacturing capability, unmatched customer support... and discretion. In a word, UDS modems give their products the kind of reliability they like to claim as their own.

UDS has a broad selection of OEM "standard" designs on file; we also offer industry-leading capability for the development of custom boards. Combined, these two approaches have already placed more than 3,000 modem designs into active field service.

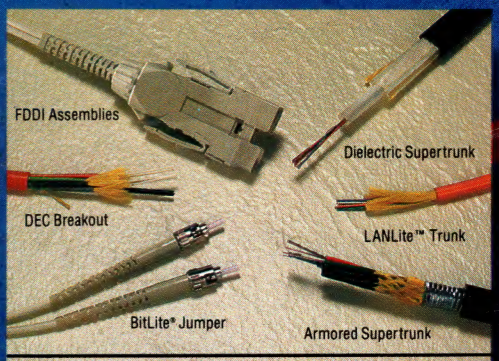
If you're one of the big boys — or if you want to solve data-comm problems the way the big boys do — find out what UDS recommends as a cost-effective solution for you. Contact UDS, 5000 Bradford Drive, Huntsville, AL 35805-1993. Telephone 205/430-8000; FAX 205/430-8926.

UDS

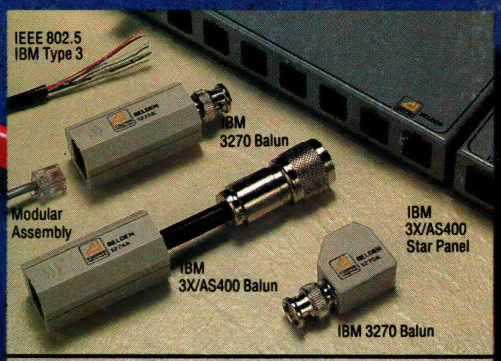
MOTOROLA

Created by Dayner/Hall, Inc., Winter Park, Florida

CIRCLE NO. 177



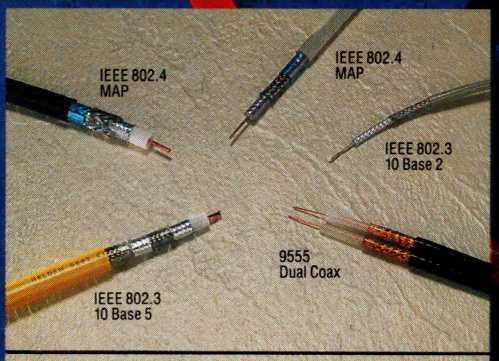
FDDI Belden® Fiber Solutions



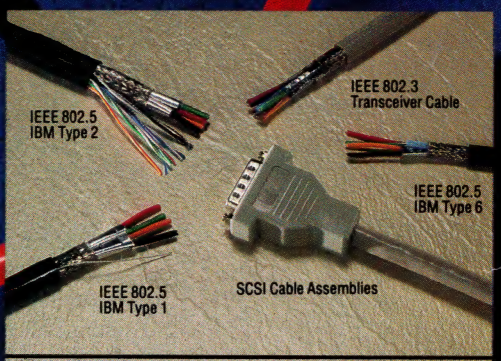
Belden® OWL® Solutions

BELDEN

The Connection For All Your LAN Cable



Belden® Coax Solutions



Belden® Shielded Solutions

Belden Simplifies Networking
Your system is only as good as its connection. Belden helps you make the right connection to ensure system uptime, comply with regulations for premise wiring and prepare your company for its future network plans. That's no small task. It takes a resourceful company like Belden to keep abreast of system developments, help drive industry network standards and manufacture reliable cable solutions to meet a myriad of requirements. Belden helps you protect your system investment.

Belden—The Source You Can Trust
Because Belden offers the most extensive and unique cable solutions, you can rely on us for an unbiased recommendation of the right cable for the job. No one matches Belden's selection of unshielded twisted pair (UTP) and OWL™ accessories, shielded twisted pair (STP) and coaxial cables, fiber optic cables and assemblies. Whether your need is for Ethernet† or Token Ring, shielded or unshielded, metallic or fiber, Belden has a reliable cable for every application. New Flamarrest™ cables present even more options as low cost plenum alternatives meeting NEC* requirements.

How To Get The Help You Need
A simple call to Belden today will provide you a personal copy of Belden's LAN Catalog and refer you to:

- A Belden Network Specialist for cabling consultation, or
- The Belden Distributor nearest you to supply your cable needs, or
- The Authorized Belden Systems Integrator nearest you for system design, hardware, cabling, installation or maintenance services.



1-800-BELDEN-4

Belden Wire and Cable, P.O. Box 1980, Richmond, IN 47375

*Tradename of National Fire Protection Association, Quincy, MA.

† Xerox trademark

COOPER INDUSTRIES BELDEN

Copyright © 1990 Cooper Industries, Inc.

CIRCLE NO. 178